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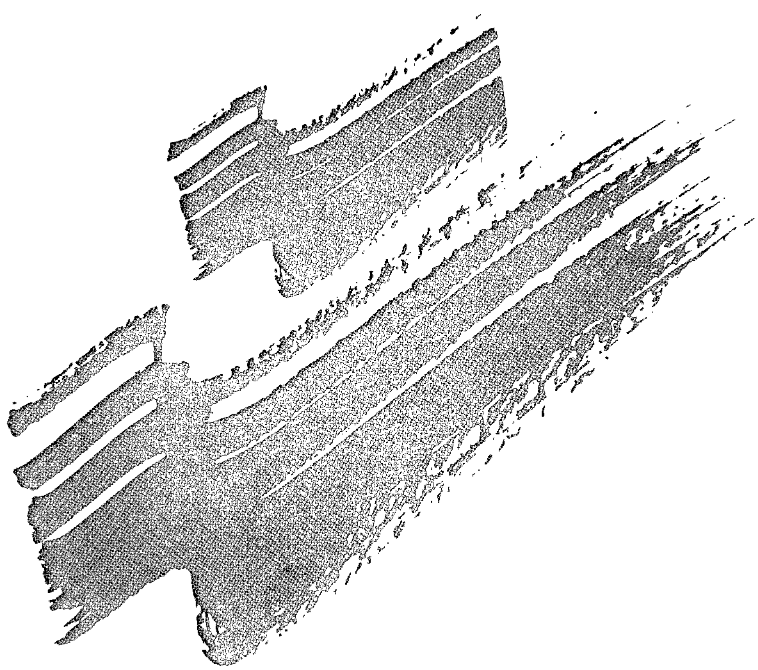
An Examination of Transportation Industry Productivity Measures



SEARCHING FOR SOLUTIONS
A Policy Discussion Series
Number 8

An Examination of Transportation Industry Productivity Measures

Summary of Proceedings:

Highway-Related Transportation Industry Productivity Measures Symposium

Sponsored by the Office of Policy Development
Federal Highway Administration

November 19–20, 1992
Arlington, Virginia

The following is a list of other publications in the Federal Highway Administration's "Searching for Solutions: A Policy Discussion Series."

Number 1	March 1992	Exploring the Role of Pricing as a Congestion Management Tool
Number 2	June 1992	Exploring Key Issues in Public/Private Partnerships for Highway Development
Number 3	August 1992	Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment
Number 4	August 1992	Assessing the Relationship Between Transportation Infrastructure and Productivity
Number 5	August 1992	Transportation and Air Quality
Number 6	December 1992	Examining Congestion Pricing Implementation Issues
Number 7	December 1992	Edge City and ISTEA—Examining the Transportation Implications of Suburban Development Patterns

Foreword

This report summarizes the results and recommendations of the Highway-Related Transportation Industry Productivity Measures Symposium sponsored by the Federal Highway Administration (FHWA). The symposium, held in Arlington, Virginia, on November 19 and 20, 1992, was designed to foster a more thorough exchange of ideas about the limitations of current transportation productivity measures and about prospects for more complete and consistent measures. The approximately 80 attendees from several government agencies, trade associations, the transportation industry, and academia included experts in data collection, methodological issues, policy needs, and industry analysis. Although the symposium was sponsored by FHWA, representatives of other Department of Transportation agencies, the Bureau of Labor Statistics, and the new Bureau of Transportation Statistics were involved in all symposium activities.

Transportation industry productivity measures, which are often cited but are frequently misunderstood, attracted attention most recently during the development of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, when low productivity was cited as a cause for concern. As a result, a variety of measures were proposed, reflecting the diversity of views on the productivity of the transportation industry. The Bureau of Labor Statistics, the Government agency responsible for calculating productivity statistics, attempts to provide an understanding of growth in various modes of the transportation industry through traditional single-factor and multifactor productivity measures. These measures are often criticized for their inability to reflect apparent industry performance. Data limitations and difficulty in adjusting for changes in the quality of labor input and output have hampered the calculations. In response, industry analysts representing various transportation modes have generated a vast array of physical performance and efficiency measures to focus on product and service characteristics.

This symposium provided an opportunity for participants to discuss emerging technical issues and users' needs related to transportation productivity measures. Participants investigated the available measures and offered specific ideas for improving these measures through collection of additional data or improved methodology. Panelists presented several papers discussing potential measures of the transportation industry's economic performance in contrast to traditional industry productivity measures. These presentations are summarized in this report. Also included is a synthesis of ideas, conclusions, recommendations, and priorities from the breakout discussions.

Of course, efforts to address the concerns will be ongoing, and quick solutions are unlikely. Future efforts to improve measures of productivity in the trucking industry are expected to be undertaken jointly by FHWA, the Bureau of Transportation Statistics, the Bureau of Labor Statistics, the Interstate Commerce Commission, and the trucking industry. We at FHWA look forward to continued dialogue and cooperation with many other government agencies, transportation trade associations, transportation firms, and academicians involved in this issue.

This report is the eighth issue of *Searching for Solutions: A Policy Discussion Series.* The series deals with emerging highway transportation policy issues such as congestion pricing, privatization, transportation and air quality, and transportation and economic productivity. Issue papers emanate from policy seminars sponsored by FHWA, often with the support of other Department of Transportation agencies, or from FHWA policy research. It is hoped that this series will inspire and stimulate a broad-reaching exchange of ideas and expertise on important challenges facing transportation policy development.

Madeleine S. Bloom
Acting Associate Administrator for Policy
Federal Highway Administration

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Executive Summary

Approximately 80 participants from several government agencies, trade associations, consultancy, academia, and the private sector transportation industry attended this 2-day symposium on highway-related transportation productivity measures. Symposium participants took part in five plenary sessions and two breakout sessions, in which participants were divided into three groups and charged with specific tasks designed to help generate meaningful, credible transportation productivity measures.

Papers presented during the plenary sessions covered the following topics:

- Current issues in correctly measuring transportation productivity.
- Ambient productivity trends and the measurements of transportation productivity.
- Modal freight productivity issues from the air, highway, rail freight carrier, and freight shipping perspectives.
- Quality and efficiency issues in measuring and improving productivity in the transportation sector.
- Freight transportation productivity measures.

Breakout sessions focused on important issues that must be addressed to generate meaningful transportation productivity measures, identification of research goals, and data needs in measuring productivity. Applications of transportation productivity measures and merits of specific estimates were discussed. Data collection needs by mode and potential barriers to meaningful measurement were identified by the group.

Current Issues in Correctly Measuring Transportation Productivity

Meaningful productivity statistics are important tools in the analysis of transportation industry activity. Nevertheless, the usefulness of these tools is limited by over-reliance on broad, single-factor measures. An overarching concern is whether analysts are paying too much attention to growth measures at the expense of industry efficiency or performance measures. Deregulation caused increased competition, which in turn spurred airline, railroad, and trucking industry managers to control costs and develop innovative services. These significant changes in the industry are not captured by traditional productivity measures.

The transportation industry moves 6.1 billion tons of freight and 1.1 billion passengers each year. Greater productive efficiency conserves resources and limits inflation by offsetting rising wage rates. Many of the productivity measures currently being used measure performance rather than productivity. Economists should not place too much emphasis on single-factor productivity and output measures, nor should they mistake productivity growth for improved productive efficiency.

The linkages between transportation infrastructure investment and overall economic performance have been studied extensively. Transportation's role in productive output is similar to that of factors such as prices, wages, and amenities; it is a direct, productivity-enhancing input. However, researchers studying the transportation industry lack a consistent data set and suffer from complex problems of classification.

Problems in measuring transportation productivity are magnified when analysts seek to define the linkage between transportation and overall economic performance. Analysts must distinguish between (1) productivity growth of the general economy as a consequence of changes in the transportation system and (2) productivity growth in the transportation industry overall and in its various segments.

Ambient Productivity Trends and Measurement of Transportation Productivity

Measuring the productivity of transportation is a complex undertaking, in part because the industry continues to undergo restructuring as a result of deregulation. Additionally, service industries have traditionally been difficult to measure. The standard transportation industry measurements of ton-miles (for freight) and passenger-miles (for humans) fail to account for innate differences in the services provided by different sectors of the industry.

More sophisticated measures of productivity include service efficiency (the amount of service output provided per unit of input) and service effectiveness. Another way to measure productivity is to construct a stratified transportation demand set by dividing and classifying travel demand according to the requirements for types of service and travel time. Analysts should also factor in economic and social trends that affect productivity. Changing market factors and new productive realities also affect overall productivity. Time or value measures such as dollar-miles can help analysts evaluate changes in the modal composition of transportation services.

In the ongoing discussion of measuring industry efficiency, it is important not to abstract efficiency and productivity from human purposes. Transportation efficiency may differ completely from efficiency for the service consumer.

The Difficulty of Measuring Productivity in the Motor Carrier Industry: A Case Study

Roadway Services, a holding company for several transportation firms, measures dock productivity, pickup and delivery productivity, freight bills handled per hour, and average load factors, among other measures. According to these measures, Roadway's average annual productivity growth is just under 2 percent. However, analysis by traditional productivity measures shows that growth in ton-miles per line haul power unit is about 0.2 percent. Clearly, traditional productivity measures do not accurately reflect dramatic changes in the industry, particularly the value-added benefits that the industry offers in response to customer demand and the increased emphasis on safety.

Modal Freight Productivity Issues

Although productivity measurement has different implications for different transportation modes, many modes suffer from similar methodological and data limitations.

In the air freight industry, product movement is intermodal movement, with freight being delivered to and from airports by truck. Productivity measures must take into account components as diverse as fuel, labor, administrative functions, marketing, and sales. Airlines use a number of productivity measures: revenue, with yield figures such as dollars per ton, yield per seat-mile, and revenue ton-miles; tons enplaned and deplaned; aircraft utilization; number of shipments; number of one-time shipments; and type of service provided.

Transportation analysts have learned that productivity indexes can be highly misleading unless they accurately relate the consumption of inputs to the production of outputs, measure and control for the mix of inputs, and measure and control for the mix of outputs. Experience demonstrates that productivity data must cover all of the industry that the analysis is supposed to represent; comprehensive data are sorely lacking for some segments of the transportation industry. Further, physical productivity advantages do not guarantee that services will be used, as demonstrated by the rail experience. If improved resource use and reduced freight costs are important to economic revitalization, then public policy must support these priorities.

Within the trucking industry, productivity has traditionally been measured by breaking business operations into segments such as pickup and delivery, maintenance, and line haul. These partial measurements fail to define the collection of inputs that make up an entire process and therefore give no clear indication of productivity; nor do they give any indication of the quality of service.

New Ideas for Measuring Productivity in the Transportation Sector

Transportation productivity measures have real-world applications in assessing service quality. Data derived from customer complaints indicate that there is a relationship between the customer's perception of the quality of service and actual measures indicating service quality. Furthermore, there seems to be a significant relationship between the density of the service provider network (such as a cost-efficient hub-and-spoke airline network) and quality. However, the same relationship does not appear to exist between capacity utilization and quality. Nor is input efficiency in the form of lower cost of input equivalent to productivity. Participants discussed the need to use more sophisticated methodologies in analyzing industry conditions.

Increasingly efficient highway freight transportation operations may be related to the greater productivity of inventory investment (measured in the ratio of inventory to monthly sales of manufacturing and trade). Faster, more reliable transport service enables manufacturers to hold less inventory in fewer locations; thus, inventory investment productivity may help indicate highway transportation productivity. More investigation into this possible relationship is necessary.

Freight Transportation Productivity Measures

Multifactor productivity measures (output per unit of combined labor, capital, and intermediate outputs) such as those used to evaluate the motor carrier industry are highly sensitive to the specific inputs and outputs selected and to the weights given to each of these measures. Indeed, they may not accurately reflect dynamic changes in the trucking industry. Traditional industry measures of physical productivity and performance, such as route-miles, number of terminals, and percentage of empty vehicle-miles, could help document the significant changes (including new emphasis on safety and quality) in the motor carrier industry that have occurred since passage of the Motor Carrier Act of 1980.

Transportation productivity measures form just one part of a broad program of measurement encompassing labor and multifactor measures used by the Bureau of Labor Statistics (BLS). Lack of detail on outputs and serious problems in collecting data from trucking and bus carriers limit BLS's ability to compile meaningful labor productivity measures (output per hour). Multifactor analyses also suffer from gaps in data collection. Meanwhile, industry measures of performance and efficiency calculated by transportation analysts offer a different approach to answering key questions about the benefits of transportation, especially trucking.

Issues Raised in Breakout Sessions

The three breakout groups met in two sessions. During the first breakout session, all groups were asked to select and rank the most important issues that must be addressed to generate meaningful, credible transportation productivity measures, and then each group was assigned a specific task.

Group A focused on various applications of transportation productivity measures in terms of users' purposes. The group recommended a number of alternative productivity indicators ranging from empty versus loaded miles to labor cost per ton-mile. These indicators were then evaluated according to their utility to business planners, the infrastructure investment decisions, private sector decision-makers, and public policy analysts. It was agreed that the data needs of these four groups differ; the alternative measures developed by the group were considered to be of most utility to truckers and of least utility to public policy analysts.

Group B concentrated on the various levels (corporate, industry segments, National economic, international, multi-State regional, State, metropolitan, and facility-level) at which transportation productivity measures are applied. Data gaps were identified at each of these levels for a number of transportation modes: air, rail, pipeline, waterway, bus, intercity rail, local transit, truck, and intermodal.

Group C assessed barriers to meaningful measurement. As in the other two groups, participants stressed that the data and assessment needs of private industry and public policy analysts are quite different. The usefulness of productivity measures was debated; it was suggested that indicators such as private sector performance and transportation system performance might provide more meaningful measures. Issues such as quality, safety, reliability, environmental cost, and economic cost should be reflected in any meaningful measurement.

When the groups met for a second time, all three concentrated on the research goals and data needs required to generate meaningful transportation productivity measures. The following issues were identified: the quest for more representative and complete data, the importance of taking advantage of modern data collection technology, the relationship between transportation data and the national economy, the urgency of identifying key questions for each group of data users, the relevance of efficiency measures to productivity measures, the demand for disaggregate data, the uncertainty regarding what data are available, the need to decide which data to collect, the issue of minimizing data reporting burdens on private industry, the usefulness of sampling and estimation techniques in data collection, the need to coordinate Federal data collection efforts among agencies, and the need to collect data on transportation sectors for which no data are currently collected (e.g., pedestrian and bicycle traffic).

Conclusions

The most significant catalyst for change in the transportation industry during the 1980's was deregulation. The challenge currently confronting analysts is to capture and quantify the effects of deregulation and other dynamic forces (such as increased safety and improved efficiency), thus providing a more complete statistical picture of the transportation industry. Of course, the value of such a statistical picture varies according to the user. Traditional productivity measures, with all their limitations, serve the needs of Federal planners; private industry has developed its own measures geared to its own needs.

There is a clear consensus that currently used productivity measures are too broad. The transportation industry is composed of a number of sectors; productivity measures suited to one sector may have no real application in another sector. On a broader scale, performance indicators are often confused with productivity indicators. Productive growth is not the same as productive efficiency. More sophisticated methodologies, such as those involving multifactor analysis, suffer from gaps in the data set and are extremely sensitive to the inputs selected. Problems with the data set also make it extremely difficult to quantify changes in quality and service characteristics of transportation output.

Symposium participants seemed divided about whether to revise current productivity measures or to seek a completely different means of evaluating the transportation industry. Suggested revisions ranged from improving the technology of data collection to redefining terms to reexamining the factors used in multifactor analysis. Suggested alternatives to current productivity measures included adoption of private sector performance measures and development of measures that stress productive efficiency. Symposium participants stressed the need to make productivity measures more responsive to the "real life" needs of policymakers and members of the transport industry.

Introduction

For the past two decades, the United States has experienced a slowdown in economic growth. During this time, the average annual increase in the gross national product (GNP) fell from 3.3 percent before the 1970's to 2.2 percent in recent years. Although a few economists attribute this sluggish growth to the maturing of the U.S. economy and view it as inevitable, others believe that this trend is a temporary setback that can be reversed.

Economic slowdown is closely tied to an accompanying decline in the growth of productivity, or output per unit of input. Several explanations have been offered for the recent sluggish productivity growth-shift to a service-oriented economy, declining investments in private research and development, changes in the composition of the labor force, etc. Some experts have suggested that a significant cause of reduced growth in productivity is a declining investment in and a deterioration of the country's infrastructure. Meanwhile, productivity growth estimates in the transportation sector have been cited as one area of concern.

Some sources have postulated that low transportation or highway productivity growth indicates the weak effect that highway infrastructure investment has on transportation productivity. However, many analysts assert that available data do not accurately reflect highway or transportation productivity because of methodological and statistical problems in developing the estimates. Traditionally, estimation methods have lacked sufficient data to identify and measure "service" output because of its often intangible nature. Furthermore, difficulty arises in measuring the factors that contribute to productivity, such as increased worker skills or education, technological advancements, and increases in capital investments. Procedures for estimating productivity often do not fully take into account quality improvements in service products. These difficulties make it essentially impossible to compare the efficiency of workers in service occupations with that of industrial workers.

Meaningful productivity statistics are important tools in the analysis of both public and private transportation investment decisions. Therefore, experts are concerned about the quality of transportation productivity estimates. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 created the Bureau of Transportation Statistics (BTS) within the U.S. Department of Transportation (DOT) and specifically directs BTS and DOT to compile better data. Several organizations—the Department of Labor's Bureau of Labor Statistics (BLS), the Council of Economic Advisors, the Highway Users Federation, the Senate Committee on Environment and Public Works, and the Federal Highway Administration (FHWA)—have recently expressed concern over the state of transportation productivity statistics.

This document summarizes the proceedings of the Highway-Related Transportation Industry Productivity Measures Symposium conducted by FHWA on November 19 and 20, 1992, in Arlington, Virginia. The symposium brought together approximately 80 participants (see Appendix A) to address the problems with the derivation of the currently available statistics, including the underlying methodology, and to identify additional research necessary to provide more representative measures of the transportation sector's economic performance. During the 2-day symposium, the participants attended plenary sessions and breakout discussions designed to meet the symposium goals. The agenda is found in Appendix B. Copies of select papers presented at the plenary sessions are available in draft form upon request to the following address:

Federal Highway Administration
Transportation Studies Division
Attn: Industry and Economic Analysis Branch, HPP-11
Washington, DC 20590
(202) 366-0281

Opening Remarks

The genesis of this symposium, explained **Madeleine Bloom, Acting Associate Administrator for Policy** in **FHWA's Office of Policy Development**, was the attention given to transportation productivity measures during deliberations on ISTEA. These deliberations raised several issues concerning transportation's relation to employment, economic growth, and overall economic productivity. Moreover, changes in the transportation industry over the last decade, particularly deregulation of several sectors, warrant examination of the methods used to measure transportation industry productivity.

The implications of transportation productivity measurement are important considerations for decision-makers when planning and investing in infrastructure. These issues are significant to transportation officials in both the public and the private sector. Therefore, FHWA assembled the participants—representing a variety of transportation modes with which DOT is concerned, Federal Government agencies such as BLS, transportation trade associations, academia, and the private-sector transportation industry—to explore the requirements for developing better transportation productivity measures. The specific goals of the symposium were—

- To educate participants about the importance of more accurate productivity measurement.
- To increase awareness of potential statistical improvement.
- To identify the best data available for improved measures of transportation productivity.
- To recommend needed research for future activities.
- To promote comprehension of the relationship between transportation infrastructure and economic performance.

In closing, Bloom introduced the symposium moderator, **Alan Pisarski**, a **Washington, D.C., transportation consultant**. She assured the participants that their contributions to the symposium ultimately would help transform future transportation infrastructure programs. She welcomed continued dialogue among the organizations represented in an effort to address the productivity measurement issues in greater detail.

Session 1: Current Issues in Correctly Measuring Transportation Productivity

In introducing the members of this panel presentation, session moderator **Robert Knisely, Deputy Director** of **BTS**, newly created by DOT under mandate by ISTEA, noted the timeliness of the symposium. He explained that proposals to create BTS were submitted as early as 1975, but the bill including the provision never passed. However, Congress' recent interest in transportation productivity helped spur creation of BTS. The symposium coincides with concerns about transportation productivity from various sources. Knisely commended FHWA for selecting an impressive panel whose combined experience represents decades in the transportation arena.

Changing Economics of the 1980's

According to **Eric Beshers, Transportation Economist** with **Apogee Research, Inc.**, the most significant catalyst for change in the transportation industry during the 1980's was the deregulation legislation. Before deregulation, the three major transportation modes—air, rail, and motor carrier—were operated much like public utilities, with regulated prices and protected markets. In this type of environment, managers of firms in these modes were not very concerned about controlling costs or developing innovative services to win new customers. However, deregulation drastically changed the way that firms in these modes do business. Beshers went on to discuss the following legislative actions that may have led to productivity increases in various segments of the transportation sector:

- Airline deregulation.
- Trucking deregulation.
- Railroad deregulation.
- The Surface Transportation Act of 1982, which increased truck size and weight limits.
- ISTEA.

The result of deregulation for the airline industry was an enormous increase in competition despite numerous mergers that occurred in the 1980's. However, the increased competition did not come from new carriers, as was expected, but from existing carriers expanding their markets by "invading one another's turf." The most significant change in airline operations, according to Beshers, was the emergence of the hub-and-spoke configuration.

Deregulation of the motor carrier industry triggered a tremendous explosion in the number of trucking firms, particularly those with for-hire authority, and in the number of brokers. Associated with this tremendous growth was the emergence of the very efficient long-haul truckload trucker. Working together, the brokers, or freight forwarders, and the truckload truckers have squeezed many of the less-than-truckload (LTL) firms out of business because they offer better service at lower rates.

Deregulation had similar effects on the railroad industry. One important change was the introduction of contracts whereby the railroads can offer tailored services and rates to some customers. Partially in response to deregulation, railroads have improved their labor agreements. Carriers' use of two crew members per over-the-road train now as opposed to five or six before deregulation has led to a drastic reduction in costs.

Since deregulation occurred, two more major transportation acts have been passed that have affected transportation productivity. The Surface Transportation Act of 1982 introduced a large increase in financing for highway programs but imposed an additional 5 cents in fuel taxes. It also allowed the use of larger trucks with increased weight limits. Again in 1991, ISTEA offered a huge increase in funding for transportation projects. According to Mr. Beshers, other significant changes brought about by ISTEA are the shift of power from State DOT's to metropolitan planning organizations (MPO's) and a new flexibility in the highway program that allows greater use of highway funds for mass transit, if State and regional officials desire.

Although some people predict that this new flexibility will bring major changes in the use of highway funds, i.e., that more funds will be earmarked for mass transit, Beshers expressed uncertainty whether this type of change will occur. The private automobile has remained the predominant mode of transportation. Its market share increased during the 1980's as vehicle miles traveled (VMT) per traveler increased and passenger occupancy rates declined, despite large investments in mass transit during the same period. Beshers predicted that, if any changes occur in this trend, they will come as a result of the Clean Air Act Amendments of 1990, which mandate reductions in emissions. Whether these efforts will succeed is anyone's guess, according to Beshers, and the process will be extremely interesting to observe. As the transportation community investigates the issue of transportation productivity measures, it is important to keep in mind these "productivity shocks" (i.e., changes in the regulatory environment).

The Transportation Industry Moves America: Freight and Passengers

"Is the transportation industry doing a good job in providing mobility for people?" asked **Bahar B. Norris, Ph.D., Senior Economist** at the **U.S. DOT Volpe Center,** as she began her presentation on current freight and passenger service productivity trends in the United States. The transportation industry moves 6.1 billion tons (5.5 billion megagrams) of freight and 1.1 billion passengers each year. Although differences exist between freight and passenger transportation, the key issue, according to Norris, is how efficiently the job is done.

As shown in Table 1, the overall transportation share of the GNP has been declining in recent years because of a decline in the share of the freight bill. Norris questioned whether this decline indicates a rise in productivity. She suggested that there might be a conflict between the goals of productivity growth and productive efficiency. Furthermore, she questioned whether the changes brought about by deregulation might paradoxically result in growth of productivity but decline of productive efficiency.

Productivity, according to Norris, is the ratio of the percentage of growth in output relative to inputs of capital and labor. Output is what the industry produces and is usually measured in ton-miles, passenger trips, or passenger miles. An increase in the ratio of output to labor and/or capital indicates a shift in the production function and benefits the economy by helping it achieve greater productive efficiency through conservation of scarce resources, mitigation of inflation by offsetting rising wage rates and other input prices, and lowering prices of domestic products, thereby enhancing trade competitiveness.

Norris defined two types of productivity measurements:

- **Single-factor productivity measures** (those currently used most often), which consider changes in only a particular input such as labor units.

Table 1.—Selected BLS Productivity Statistics

Transportation Mode	1947–89		1988–89	
	Annual % Change Output Per Employee	Annual % Change in Output	% Change Output Per Employee	% Change in Output
Rail Freight	4.5	0.6	6.4	2.2
Intercity Trucking	2.7	3.6	4.0	2.0
Passenger Bus	-0.5	-1.2	-0.1	-0.1
Transit	-5.7	NA	NA	NA
Air Transportation	5.9	10.1	-3.5	3.3
Oil Pipelines	1.3	1.2	-6.8	-6.2

- **Total-factor productivity measures,** which consider all factors of production, including changes in capital inputs.

In addressing passenger transit productivity trends, Norris noted that single factor productivity measures in the passenger transit industry indicate that both labor productivity and output have been declining. Numerous analyses have shown that passengers are taking fewer trips and are traveling fewer miles. Transit agencies have acknowledged a concern over high labor costs and have attempted to remedy the problem by hiring more part-time workers, matching offered services with passenger demand, and employing competitive contracting. However, in the case of buses, despite the decline in output, prices and revenues have been rising since the early 1980's. Norris emphasized that transit prices and operating revenues should not be used interchangeably with productivity measures. **Indeed, many of the so-called productivity measures, such as revenue per mile and cost per employee, are "performance" and not "productivity" measures.** Norris suggested that, instead of passenger miles, a more appropriate measure of the industry's productivity might be in the availability of transit services, because this measure is directly connected to the purpose of transit, i.e., to meet the passenger's need for mobility.

In the next phase of her presentation, Norris offered a discussion of trucking and rail productivity measurement issues in light of her discussion of the transit concerns. She focused on five issues:

- Price changes, which are not the same as physical productivity.
- Lack of productivity statistics for major segments of the transportation industry.
- Inadequacy of single factor productivity and output measures.
- Impact of shifts in mode share.
- Industry productivity versus productive efficiency.

First, Norris noted that changes in price are not the same as changes in productivity. Price reductions that occurred in the 1980's in this segment of the industry were the result not of productivity factors but of increased competition, declines in diesel fuel prices, and the "squeezing out of excess profits." Price declines caused by these factors marked changes in economic efficiency of the market, not a growth in productivity. Only those price declines that can be attributed to an increase in the physical efficiency of production can be considered in measuring productivity gains.

The second area of concern is that major segments of the trucking and rail industries are not covered by productivity statistics. Only about 11 percent of the trucking industry is included, and although about 80 percent of Class I railroads are included, the remaining 20 percent, which are regional, short-haul carriers, are not included.

Third, Norris warned that economists should not place too much reliance on single-factor productivity and output measures. Excluding capital inputs makes productivity measures artificially high and leads to an overestimation of productivity gains. Norris suggested that freight ton-miles may not be the best measures of output and that other measures such as maintenance of terminals, equipment, and right-of-way should be considered.

Fourth, Norris informed the participants that, between 1940 and 1989, the rail freight industry dropped in market share for intercity freight ton-miles from 61 percent to 37 percent. During the same period, trucking gained in market share from 10 percent to 25 percent. Meanwhile, rail revenues increased by only 7 percent, and trucking revenues increased by 64 percent. According to Norris, although the economy has gained in physical productivity from this mode shift, it may have lost in efficiency of resource usage.

Finally, Norris noted that when analyzing industry productivity, the impacts on productive efficiency must also be weighed. For example, the railroads generated about 1 trillion ton-miles of freight transportation in 1989, as opposed to 700 billion ton-miles generated by the trucking industry. Revenue per ton-mile in rail was only 2.67 cents, and trucking received 23.21 cents in revenues per mile. However, the trucking industry used 407 billion barrels (64.7 trillion liters) of fuel for this period, while the railroads used only 79 million barrels (12.6 billion liters). Freight traffic continues to be diverted from rail to trucking despite rail's cost advantages, fuel efficiency, and environmental benefits. According to Norris, the shift in market share and in resources from rail to trucking can be detrimental to the country's economy and to productive efficiency, even though nominal productivity figures indicate high growth. Although

Norris did not say one measure was better than the other, she emphasized the importance of looking at both measures.

Transportation's Role in Economic Performance

Recent predictions that investment in public infrastructure could be a boost to economic development have heightened interest in the link between infrastructure and the economy. According to **Randall Eberts, Ph.D., Assistant Vice President** and **Economist** of the **Cleveland Federal Reserve Bank**, it is important to understand the difference between transportation infrastructure's effect on overall productivity and increases in transportation productivity in and of itself. Eberts addressed the issue of transportation infrastructure's impact on overall economy-wide productivity to add perspective on how transportation industry productivity should be measured. Recently, the linkages between transportation investment and economic performance have been studied extensively and in a number of ways, primarily in attempts to explain the slowdown in productivity that has occurred in the last 10 years. Factors that may slow economy-wide productivity growth include:

- The changing composition of the labor force.
- The slow growth of private capital stock.
- Increases in energy prices.
- A decline in investment in research and development.
- A diversion of capital resources to pollution abatement.
- The shift to a service-oriented economy.
- The mismeasurement of output.
- Declines in public infrastructure investment, such as in transportation.

Because many explanations have been suggested for the recent slowdown in the economy, there is much controversy about the role of the declining investment in public infrastructure on the slowdown of productivity.

To examine the role of these various factors, economic analysts have implemented a framework, based on a macroproduction function, with three variables: labor, private capital stock, and public capital stock. Eberts believes that putting transportation infrastructure into such a framework is appropriate. Transportation is essential for production because people and materials must be brought together in order for production to take place. However, this type of framework does not fully account for the subtleties of the factors outlined above or the spatial arrangement of economic activities, which make transportation so necessary for production.

Eberts maintained that several levels of economic performance must be considered in linking overall economic productivity with public capital infrastructure. First is the transportation facility itself—the highway or mass transit facility (the actual combination of equipment and structures) whose efficiency is important to economic performance. Next is the transportation industry as a whole—how the elements, such as airlines and airports, work together to provide productive services. The next levels are aggregation levels that range from the local economy to the international economic picture.

At the regional level, it is easy to see transportation as an input that goes directly into the production function process. However, public transportation infrastructure also indirectly affects or augments the other factors of production; i.e., when workers can travel to their jobs in an efficient manner, the private capital investment performs more efficiently. Public infrastructure also attracts other inputs into production. Businesses and workers are attracted to areas that have good highways and accessible air travel. In addition to these effects, there is also the traditional linkage of public infrastructure to job creation, indicated in the question, "How many jobs will building a highway create in my city?"

Thus, production output percolates from very subtle effects from the bottom level, such as prices, wages, and amenities. Transportation infrastructure links to these aspects as direct, productivity-enhancing input that creates new markets and improves human capital for certain areas by improving the networks for spatial arrangement of the factors that lead to productive output. These effects of transportation infrastructure can be measured through output, services, personal income, sales, and various productivity measures.

To develop a framework for determining the role of transportation in economic performance, Eberts suggested considering the following factors: the level and quality of the service of transportation facilities, the differing effect of infrastructure on different types of industries, the changing locations of production (from the inner city to the suburbs, for instance), alternatives to investment in infrastructure (such as congestion pricing), the relative productivity of different types of infrastructure, and networks that bring markets and people together.

Issues in Meaningful Measurement

Paula C. Young, a **Senior Economist** at the **Bureau of Economic Analysis (BEA)**, used information prepared by BEA to identify what she maintains are key problems that need to be resolved to provide an adequate statistical base for a good analysis of transportation productivity and other related issues. She used data drawn from BEA's input-output (I-O) accounts, which integrate data from a variety of sources to show the production of commodities (goods and services) by industry, the use of commodities by each industry, the commodity composition of gross domestic product (GDP), and the contribution of each industry to GDP. These accounts are unique, according to Young, because they completely account for commodity production and use for the entire economy. They present a comprehensive picture of the economy because the detailed information they provide on products and industries disaggregates the GDP and provides a detailed mapping of the interrelationships of industries as producers and consumers.

These interrelationships, Young explained, are evident in the two tables that are basic to the I-O accounts—the I-O Make Table and the I-O Use Table, shown in Appendix C. The I-O Make Table (Table C1) shows the production of each commodity in the economy, by industry, and the I-O Use Table (Table C2) shows the commodities consumed or used by each industry and by final consumers.

The statistics for individual industries in the I-O accounts are collected, tabulated, and published according to the Standard Industrial Classification (SIC) System. Transportation industries are organized within the SIC codes and the I-O framework primarily by mode of transportation, except for one major group, which includes a number of incidental transportation services. The data are reported typically by establishments or physical locations, which are categorized by SIC code number according to their primary activity, tabulated by detailed industry, and aggregated into higher level groups. The detailed list of SIC's and the corresponding I-O classifications indicate that transportation industries provide a variety of commodities, such as the movement of persons, the movement of freight, and support services to facilitate the movement of persons and freight.

Table 2 shows the commodity output for each of the transportation industries in the I-O accounts and distinguishes between persons-related and goods-related transportation activities. For the goods-related activities, it also indicates revenues associated with goods transactions, or **margin**, and those not associated with transactions (i.e., **direct sales**) such as moving office locations or other activities that do not involve the sale of goods.

I-O accounts identify some interesting features of the transportation industry, Young noted. For example, Table C1 shows that government produces $4.5 billion worth of transportation.

Table 2.—Composition of Commodity Output for I-O Transportation Industries (millions of dollars)

	Rail	Bus, Taxi	Truck Warehousing	Water	Air	Pipe	Arrangement of Freight Trans.	Arrangement of Passenger Trans.	Trans. Total
Commodity Output	30,550	12,330	74,320	23,043	44,245	7,981	2,621	4,270	199,960
Persons Related	918	12,806	—	936	33,270	—	—	4,270	52,200
Goods Related	29,632	124	74,320	22,107	10,975	7,981	2,621	—	147,760
Margin	26,161		45,909	5,912	3,270	7,795	—		89,047
Direct Sales	3,471	124	28,411	16,195	7.705	186	2,621	—	58,713

Table 3.—Use of Transportation Related Commodities (millions of dollars in 1982 purchasers' prices)

Commodity	Total Use by Business & Government	Percent Purchased by	
		Transportation Industries	Others
Gasoline	40,711.2	36.2%	63.8%
Diesel Fuel (excl. heating)	31,198.4	39.5%	60.5%
Tires	2,296.1	53.8%	46.2%
Auto and Truck Parts	4,213.6	11.3%	88.7%
Motor Vehicle Insurance	2,495.4	8.0%	92.0%
New Autos and Trucks	3,983.9	75.6%	24.4%
Auto Repair	13,216.5	8.6%	91.4%

From the detailed I-O accounts, the specific commodities produced can be determined. In this case, the commodity produced is bus transit, and it represents 28 percent of the total highway passenger transportation. Table C2 shows that transportation industries are not as heavily labor intensive as most service industries. However, they require a substantial capital investment in vehicles and in intermediate inputs such as fuel, tires, etc.

The commodity consumption data contained in the I-O accounts show that not all transportation is performed by transportation industries, i.e., that many businesses, such as wholesale and retail trade and manufacturing, supply their own transportation services. Table 3 shows the use of transportation-related commodities by all businesses. The last column shows that nontransportation industries use a significant portion of these commodities. These percentages indicate the degree to which industries are providing their own transportation services.

Whether the businesses provide these services at their main establishments or at separate locations is irrelevant. Regardless, the data for these transportation operations are not included in the SIC data for the transportation sector; rather, these data may be included separately as auxiliary operations to the main SIC classification. However, these auxiliary operations, which include functions such as central administrative offices, are not reported separately by function. Thus, the current SIC distinctions make compiling complete data for transportation extremely difficult.

Industry output for the I-O accounts is measured in terms of receipts, and the data are supplied by the quinquennial economic census. However, only certain transportation SIC codes are included in this census, and these have been covered only since 1987. Table 4 shows the source data used in preparing the output estimates for transportation in the BEA I-O accounts. The table reveals broad inconsistency in the sources and in the method of estimation. The table displays several examples that use the indirect method; for example, BLS wage and salary estimates are used to compute a factor to cover nonlabor inputs.

In summary, Young reiterated that the transportation industries suffer from a lack of a consistent data set and a complex problem of classification, which make the data and any estimation of transportation relative to the economy as a whole suspect. Although the 1992 economic census will improve the statistics by covering more segments of the transportation industry, gaps remain. Universal data cannot be collected with assurance of its reliability until all areas are covered.

Discussion

From the highway user's point of view, transportation productivity can be a big contributor to the bottom line of U.S. industry, stated discussant **Lester Lamm, President** of the **Highway Users Federation**. When the bottom line increases, the industry employees and customers prosper; when it decreases, businesses begin to fail. Most people believe that there is a link between the level of service provided by the transportation industry and overall productivity or economic vitality. Unless that link is totally incorrect, benefits to transportation industry productivity should benefit economic vitality.

One question is whether transportation industry productivity is increasing or decreasing and by how much. During the deliberations for the ISTEA legislation, the Senate committee maintained that the overall transportation productivity growth was only 0.2 percent per year for the last several years. They believed that this figure reflected a need for significant changes in the implementation of public-sector

Table 4.—Principal Source Data and Estimating Methods Used in Preparing I-O Gross Output

Industry	Receipts Source
Railroad	Interstate Commerce Commission (ICC), Transport Statistics in the United States
Local and Interurban passenger transit	
Taxicabs	DOT special survey
Intercity buses	American Bus Association
School buses	Bureau of Labor Statistics (BLS) wages and salaries and private association data for nonlabor estimate
Local transit	BLS wages and salaries, BLS and Census Bureau (Census) data for nonlabor estimate
Trucking and warehousing	Pre-1987, ICC for regulated portion and Census for nonregulated; 1987, Census Bureau quinquennial censuses
Water transportation	Pre-1987, BLS wages and salaries and private association for nonabor estimate Also ICC and Census foreign trade statistics 1987, Census Bureau quinquennial censuses
Airlines	FAA operating revenues of scheduled air carriers
Pipelines, except natural gas	Federal Energy Regulatory Commission
Transportation services	
Arrangement of passenger transportation	Census Bureau quinquennial censuses
Arrangement of freight transportation	BLS wages and salaries and Census data for nonlabor estimate Transportation Policy Associates and Air Freight Forwarder Statistics

transportation investment programs. However, many experts asserted that the figures do not reflect the situation accurately. Rail productivity may be closer to 8 percent per year, and highway productivity may be more than 3 percent.

Lamm agreed that changes in transportation productivity over the last decade have reflected public activities, which cross partisan positions. However, he asserted that several changes in public policy, particularly concerning deregulation, have been made without consideration of the full impact of those changes. Lamm maintained that several issues raised by the panelists warrant further consideration:

- How useful is an aggregated figure of transportation productivity when statistics show wide differences in productive performance among different transportation modes?
- How should transportation productivity be defined and measured across and within the different transportation modes?
- How can methods of acquiring data be developed to include all transportation activity?
- Should the pertinent statistics be transportation productivity, or should they indicate, as Norris maintained, productive efficiency of the transportation industry?
- What role should customer satisfaction and private-sector performance have in productivity measurements?
- Should the United States spend much effort in measuring its domestic transportation productivity in isolation, or should it be working with other nations so that future evaluations of performance throughout the world are based on the same factors and types of measurements?

In addition to these issues, transportation officials must consider the impact that emphasis on different elements of ISTEA might have on transportation productivity; i.e., which improvements in the funding apparatus will provide the most long-lasting positive impacts?

The second discussant, **Paul Roberts, President** of **Transmode Consultants**, cautioned that, in measuring transportation productivity, economists and transportation officials must not confuse two important aspects of productivity growth:

- Productivity growth of the general economy as a consequence of changes in the transportation system.
- Productivity growth of the transportation industry and its segments in and of itself.

By definition, productivity is outputs divided by inputs. Therefore, to increase productivity, one must either increase outputs or decrease inputs. Although the formula seems straightforward, the panelists offered several explanations of why the measurement of inputs and outputs, and thus the measurement of productivity, is complicated.

The issues are further complicated in the transportation arena, Roberts asserted, by the different outlooks of economists and engineers. Frequently, economists measure productivity in terms of dollars, whereas engineers measure productivity in physical terms. Although highways may be very productive in physical terms, they are very unproductive in terms of dollars. Roberts questioned whose viewpoint should be given the greater weight in determining productivity.

When one attempts to measure transportation productivity, it may be helpful to understand the factors that may cause increased productivity in this sector. Roberts listed several ways to improve transportation productivity:

- **Increasing the connectivity in a sparse network.** Adding new links in the highway network, such as bridges, tunnels, and bypasses, decreases mileage and travel time and thereby increases overall productivity.
- **Increasing service levels on existing links in the network.** Eliminating capacity constraints in specific areas of the highway network, by adding lanes, improving the pavement quality, etc., also increases productivity by saving time, fuel, and other inputs.
- **Improving the efficiency of existing operations.** For example, highway productivity is enhanced by increasing vehicle utilization, increasing throughput on highway facilities, and reducing empty miles for freight transporters.
- **Reducing the costs of primary inputs.** One result of deregulation was the conscious effort to reduce labor costs. However, the relative costs of equipment and facilities can also be reduced by using them to the fullest extent possible.

Roberts maintained that an important aspect of measuring productivity is to identify causal relationships. He recommended considering the following aspects as potential measures for transportation productivity: (1) the increased carrying capacity of trucks, (2) the change in types of products that are being transported (e.g., ton-miles may not be the best indicator for today's lighter weight, more valuable products), and (3) the trend toward smaller inventories in stores and more frequent shipment from a centralized warehouse. Although this trend accounts for higher transportation costs, centralized housing and control of inventory reduces overall costs for the merchandiser, thereby increasing productivity. Unless these causal mechanisms are identified, the results of econometrics will be misleading and confusing, according to Roberts, because they will not reflect the true picture of transportation productivity.

Session 2: Ambient Productivity Trends and the Measurement of Transportation Productivity

Taking issue with recent assessments of productivity growth in the transportation industry, **Alan Pisarski** asserted that the transportation industry is not moribund, as some have suggested; but rather the transportation statistical system is moribund. Several factors contribute to the difficulty in measuring transportation productivity, such as industry restructuring with deregulation, and the general difficulty in measuring services. This difficulty in measuring services, Pisarski maintained, lies behind the real problem in forming more meaningful productivity measures. The classic issue is the conceptual dilemma in defining the output of transportation services and determining how to measure that output. Although billions of dollars of transportation services are purchased each year, the industry still lacks a clear definition of the product provided.

The standard measurements of transportation output are ton-miles (for freight) and passenger miles. However, according to Pisarski, different sectors of the industry measure these outputs in different ways, and a comprehensive survey of measurement methods is needed at the outset of an evaluation of productivity measures. Furthermore, these measures are inadequate because they fail to account for innate differences in the service provided. For example, these measures appear to equate passenger miles in a rowboat with those on an ocean liner, ignoring the quality of the service provided. They do not consider the value of the products served, appearing to equate the ton-miles for a ton of coal with those of a ton of computer chips. The measures also fail to take safety and reliability of the service into account; a shipment of a ton of bricks is treated in the same manner as a shipment of a ton of orchids. Finally, these measures do not recognize the most important element of most transportation services, which Pisarski maintained is speed.

Pisarski contended that the reach of statistics needs to be extended into more sophisticated expressions of productivity. He cited the Section 15 reporting system of the Federal Transit Administration, which measures what it calls "service efficiency," or the amount of service output provided per unit of input. Section 15 also considers service effectiveness, which includes factors such as the loading, e.g., whether all of the seats on an airplane are filled. In other words, service effectiveness involves how effective the service provider is in ensuring that the provided service is consumed. The distinction in these two measures, according to Pisarski, is that "efficiency is doing things right, whereas effectiveness is doing the right things." When converted to dollars, these measures of service efficiency and service effectiveness also indicate cost efficiency.

Differing characteristics of passenger and freight travel offer some interesting implications for measurement of productivity, noted Pisarski. For example, the value of travel time to passengers varies greatly according to the occasion and may even be irrelevant in some travel modes, such as ocean cruise liners. However, the movement of freight entails a value-based component, in terms of the dollars involved, that includes both time and inventory value. Also, passengers can assist in the productivity process by performing intermodal moves. However, passengers have very special packaging needs that must be met if the service provider expects to avoid their complaints and keep their business.

Because of these different characteristics, Pisarski recommended that a potential mechanism to improve the productivity measurement process would be to construct a stratified transportation demand set by dividing and classifying travel demand according to the requirements for types of service and travel time. Then measures of service provided and productivity could be structured around how well the transportation industry responds to the demands in terms of investment and services provided to the different demand strata.

Changes in productivity often occur as a result of economic and social trends that are independent of events within the transportation industry. Pisarski coined the term **"ambient productivity effects"** for trends such as the following:

- Changes in the composition of the cargo base, such as an increase in shipments of consumer goods over those of commodities.
- Changes in trip length, both in passenger and freight transport, which increase passenger miles and ton-miles and thereby increase productivity.
- Changing geographic patterns, such as increased congestion in some areas.
- Congestion is a strong negative ambient productivity factor for trucking and urban transit buses, according to Pisarski, because it reduces speed and reliability and is beyond the carriers' control.

Statistics show that ton-miles per capita continue to increase, while ton-miles per unit of GNP continue to decline. Pisarski questioned whether this trend is an indication of increased productivity. He attributed the trend to several factors, all of which affect the amount of ton-miles: the reduction in size of most commodities produced (such as televisions, automobiles, and computers), the purchase of goods outside the country, and the shift from a manufacturing economy to a service-oriented economy.

These changing market factors cause either a decline or an increase in demand for specific transportation services and thereby affect the productivity of different transportation sectors. In a declining demand case, such as that experienced by the railroads following deregulation, the industry must reduce inputs to conform to declining demand without reducing supply of services to the point that demand is further reduced. The U.S. railroad industry achieved astonishing productivity in this type of environment. In an increasing demand case, reflected by the recent experience in trucking, the industry must invest properly and wisely to offer the types of services that meet the demand.

The emergence of new productivity, such as that from new technologies, within the general economy also can have long-term effects on transportation productivity. Pisarski called these changes "exogenous productivity." For example, the introduction of facsimile machines, the widespread use of computers, and new communications technologies have all had a significant impact on transportation. Some of these technologies may be a substitute for transportation, and others may enhance the capabilities of transportation industries. For example, car rental companies can now offer one-way rentals because technology allows them to track reservations and the location of all rental vehicles.

The current productivity measures are misleading also because they do not reflect changes in the modal composition of transportation services. For example, the shift in freight transportation from rail to trucking has resulted in an apparent increase in the cost of ton-miles of travel. However, trucking offers speed, service quality, security, and reliability—factors that, as Pisarski previously noted, are not included in current productivity measures. The introduction of a time or a value productivity measure, such as dollar-miles, would change the statistical view of trucking to that of a productivity leader.

Pisarski also raised issues about the current demand for increased intermodal transportation for both passengers and freight and the implications for productivity measurement. First, the measurement of terminal productivity is very complex and difficult, given the array of activities and types of facilities involved, and this type of measurement has continued to be a private issue within the industries. Second, intermodal transfers are inherently unproductive, and the costs in time delay and equipment for transfers must be overcome by greater productivity in the second mode, if overall productivity is expected to increase. Therefore, the development of joint measures of productivity for intermodal transport will need careful consideration.

Finally, Pisarski warned that the word "efficiency" rarely has a useful meaning in relation to transportation unless it is carefully clarified, and it can be dangerous in the transportation community. Although larger trucks, mass transit, and the hub-and-spoke system in airports are all more efficient, they may simply shift cost burdens from the producer to the consumer. Furthermore, transportation efficiency may differ totally from efficiency for the consumer. For example, the practice of delivering Domino's Pizza one at a time is extremely inefficient from a transportation standpoint, but from the consumer's point of view, it is extremely efficient. Thus, the place of transportation productivity and efficiency in the overall efficiency of the economy is an important consideration in measuring productivity. If these factors are not measured adequately, the transportation industry may receive false signals that it is not as productive as it should be. Finally, as the individual in both passenger and freight travel become more valued, the statistics will diverge sharply from reality.

Discussion

The participants raised several issues in response to Pisarski's presentation. One person noted that another danger in measurement of output in ton-miles across the transportation industry is that it does not account for conditions that affect the measurement, such as a change in the way petroleum is moved from one part of the country to another.

The issue of the differences between productivity and efficiency raised several questions. Responding to a request for clarification of the Domino's Pizza delivery example, Pisarski explained that whether it can be considered productive or not depends on how resources are defined. If the consumer's time is considered as a resource in addition to the use of the driver and vehicle, then the equation may work out correctly. He reiterated that the implications of always considering mass movement as more efficient than individualized movement may not be attractive to society and that efficiency and productivity should not be abstracted from human purposes. One participant pointed out that an automobile and an 18-wheeler carrying pizzas represent two entirely separate production functions with their own embedded measures of productivity and efficiency.

One participant disagreed that speed of service is a driving factor in the transportation industry and emphasized reliability as an important factor. The trend in society, replied Pisarski, is toward high value, and speed will be a factor because of inventory costs. However, he repeated the importance of responding to the demand set and again recommended constructing a stratified demand set.

Luncheon Presentation: The Difficulty of Measuring Productivity in the Motor Carrier Industry

As he prepared his presentation, related **Timothy Lynch, Vice President** of **Government Affairs** at **Roadway Services, Inc.**, he initially intended to discuss why the often cited statistic presenting a low transportation productivity growth rate (0.2 percent) is "all wet." However, after studying several statistics from his own company, he changed the theme of his presentation to "why measuring productivity in the motor carrier industry is difficult."

Few industries compute and analyze productivity numbers more than the motor carrier industry, according to Lynch. For example, Roadway Services, which is a holding company for several transportation firms, measures dock productivity, pickup and delivery productivity, freight bills handled per hour, and average load factors, among other measures. Each individual terminal has its own measures. Lynch used these figures in an effort to analyze productivity at Roadway.

Lynch began with some basic yardsticks of growth for Roadway from 1978 to 1991:

- Total shipment weight increased from 6 million tons to 7.2 million tons (5.4 to 6.5 million megagrams).
- The intercity, over-the-road fleet increased in number from 3,135 to 3,159.
- Total employees increased from 23,000 to 25,000.
- The average shipment weight decreased from 1,174 to 1,080 pounds (533 to 490 kilograms).
- The average length of haul increased from 988 miles to 1,210 miles (1,590 to 1,947 kilometers).
- The terminal count increased from 455 to 610.

Lynch's initial view of productivity numbers was encouraging. He found that Roadway delivered 29 percent more less-than-truckload tons in 1991 than in 1986 with only 3 percent more management employees, and between 1978 and 1990, the company handled 23.5 percent more ton-miles with 11 percent less fuel consumption. However, as he began to apply traditional productivity analyses to these figures, he discovered that growth in ton-miles per line haul power unit was not significantly better than past citations of low productivity growth rates in the transportation sector.

Lynch then examined other statistics such as dock pounds per hour, number of accidents per number of miles traveled, and average tractor length. He explained that he used 1978 as his base year because it represented a stronger baseline than that of 1982, when the industry was in recession. Finally, he computed the standard measurement of ton-miles per employee, skewed slightly with factors related to shipments. He found an average annual productivity growth rate of just under 2 percent. He attributed much of the productivity growth rate in his company to the conversion of its tractor fleet from primarily a single-trailer fleet to an 85 percent double-trailer fleet in 1986. He applied the same methodology to the overall industry rate and found a significantly lower rate.

An informal survey of Lynch's coworkers revealed that many were not surprised to find productivity growth rates of 2 percent, which was lower than Lynch anticipated. They all agreed that traditional productivity measures cannot accurately reflect dramatic changes in the industry, particularly the value-added benefits that the industry offers in response to customer demand. Although Roadway's primary product continues to be the movement of goods, advances in technology over the last 10 years have had a tremendous impact on the way those goods are moved. To illustrate this point, Lynch reported that the company's 1981 annual report devoted two sentences to its new computer tracking system. In contrast, the 1991 annual report devoted considerable space to describing the company's advanced technological capabilities. With the use of bar codes on packages and scanners at the dock door, workers can automatically update the database. Supervisors can accurately track shipments and identify those that are behind schedule or otherwise service sensitive. Shipment schedules can be easily modified. Shipments can be weighed and automatically rated and invoiced by computer. The bar code tells automatic sorters at which door to deliver specific packages. This technology has allowed Roadway to provide logistics support services that customers previously had to provide for themselves. The systems allow customers to substitute *information* for *inventory*, as Roadway's companies provide "just-in-time" parts delivery properly sequenced for the assembly line. Satellite communications allow companies to guarantee pickup of shipments within 90 minutes and delivery within 30 minutes of an agreed upon time.

Traditional measures of productivity have not kept pace with these advances, nor do they consider other factors such as increased safety. As Roadway Services converted its fleet to a primarily double-trailer fleet, Lynch reported, it handled 23 percent more ton-miles with 500 fewer accidents. A true picture of productivity cannot be obtained, according to Lynch, unless such factors as value-added services and increased safety are included in the equation.

Discussion

Participants questioned Lynch about the role of employees in the success and productivity growth of Roadway Express. Noting that one explanation of lower productivity growth may be a lower skill level of the workforce, one person questioned if this perception were true for the company. Lynch explained that the advances and growth in the company have required higher skilled workers. For instance, one terminal contains 400 doors and has 75 to 80 tow motors operating at any given time. Workers must be skilled to work in this type of environment. Lynch reported that employees are working smarter, not harder or longer hours. In addition, Roadway Express' operations are unionized, so the workforce is stable but has changed somewhat in composition. Although the number of drivers has increased, the number of support staff has been reduced through attrition as a result of increased automation and implementation of more efficient procedures.

Another participant pointed out that the increased services described by Lynch allow Roadway Services' customers to be more productive, but at a cost. Lynch explained that Roadway Services offer competitively priced products and services, which, he believes, contribute to productivity growth in the overall economy.

Session 3: Modal Freight Productivity Issues

This session, moderated by **Alan Pisarski,** consisted of a panel discussion of the implications of productivity measurement for different transportation modes. The panel members discussed measurement issues from the perspective of air freight, railroads, and shippers. This session offered broad discussion of past, current, and future measures across modes; problems with those estimates; the importance of modal measures; and recommendations for gathering additional data.

Air Freight: A Discussion of Available Measures

To understand productivity in the airline industry, according to **Paul J. Hyman, Vice President** of **Cargo Services** at the **Air Transport Association,** one must first understand the structure of the industry. Airlines represent the youngest transportation mode, and the air freight business has been a significant component only in the last 15 years, since deregulation and the birth of overnight package service and the just-in-time inventory concept.

Air freight movements are basically intermodal movements, explained Hyman; i.e., all air freight is delivered to and from the airport by truck. In fact, there are several components of the air freight system that must be considered in productivity measures: the freight forwarder and consolidator who forwards the shipment to the airport, the aircraft, fuel, labor, airport handling, administrative functions such as billing and collection, marketing and sales, brokers for international shipments, and delivery of the product. The deregulated environment has resulted in the growth of several integrated carriers who perform all of these functions under one organization. However, the industry also contains carriers who provide only airport-to-airport services. The measures of system productivity and quantification therefore vary widely.

Hyman listed several productivity measures used by airlines:

- **Revenue,** with yield figures such as dollars per ton, yield per seat-mile, and revenue ton-miles (or revenue ton-kilometers). Overall revenue for U.S. airlines last year was $71 billion, with $12 billion in cargo revenue. The total revenue ton-kilometers internationally for freight was $74 billion.
- **Tons enplaned and deplaned.** The Federal Aviation Administration uses this measure, added to the weight of the aircraft, to determine the total weight of aircraft landing at an airport. This figure is then used to determine the amount of capital funds needed for improving freight facilities of various airports.
- **Aircraft utilization.** The hub-and-spoke system, popular since deregulation, has offered greater aircraft utilization, i.e., hours of aircraft use per day.
- **Number of shipments.** The airline industry processed 741 million shipments last year.
- **Number of on-time shipments.** This measure adds a qualitative measure to productivity.
- **Type of service provided,** which differentiates between same-day, or over-the-counter, service; priority air service, in which cargo is shipped with reservations on specific flights; and general cargo service, in which packages are transported on a space-available basis. The three types of service have different performance measures.

The various measures have several implications for decisions concerning investment in infrastructure. For example, the airline industry has demonstrated that it is losing $3 billion per year because of air traffic control delays. Therefore, the industry welcomes an examination of the relationship of infrastructure and investment in infrastructure to overall productivity growth.

Railroads: Lessons To Be Learned

To be effective, stated **Martha Lawrence,** a **Principal** with **Transport and Management Consultants, Inc.,** both infrastructure development and the promotion of intermodalism must be guided by the productivity implications of prospective investments. Lawrence emphasized the importance of using a precise definition of productivity, i.e., the efficiency with which physical inputs are turned into product or service outputs by the firm or industry examined. Productivity growth, she explained, rests on real improvement in the ratio of outputs to inputs. In stressing these definitions, she also underscored the fact that price cuts should not be equated with productivity. For example, declining rail prices during the 1980's resulted from increased competition and lower diesel fuel prices, but this decline is not a productivity improvement. However, productivity improvements within the industry allowed it to remain financially viable during that period.

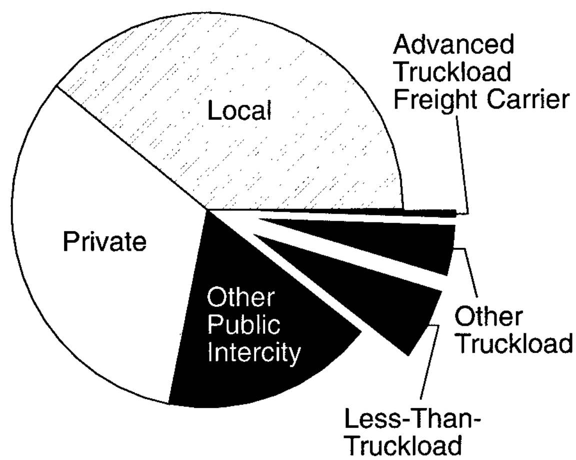
In multiproduct firms, Lawrence explained, accurate productivity measurement requires consideration of and control for multiple inputs and multiple outputs. Production of freight service requires a wide range of labor equipment, fuel, and capital inputs. Certain inputs may be substituted for others over time, making single-factor productivity measures misleading indicators of overall productivity. (For example, see Table 5, which displays the growth rate in a range of common rail productivity indices as compared to the total factor productivity index.) Furthermore, different outputs require different levels of resources to produce. Therefore, productivity measures must be able to control for output change. Otherwise, a carrier may appear to have improved its productivity even though it uses the same resources to provide vastly different services.

Table 5.—Rail Productivity Measures (Percent of Growth, 1980–88)

Productivity Measure	Growth Rate
Ton-miles per employee hour	95.0%
Ton-miles per car owned	84.7%
Ton-miles per mile of track	42.5%
Ton-miles per train hour	41.1%
Ton-miles per gallon	34.0%
Total factor productivity index	32.0%

Economists have developed total-factor productivity measures that weight the importance of inputs to a range of services and controls for the changes in the output mix. Although the procedure is complex and has extensive data requirements, Lawrence advised DOT to promote such analysis to fairly evaluate the impact of alternative investment decisions on competing modes and carriers. She cautioned that single-factor productivity measures may suggest a far greater productivity than the more rigorous total-factor approach would indicate. Furthermore, each industry tends to use the most flattering performance measures available, so transportation officials should beware of productivity claims of their constituents.

According to Lawrence, transportation officials must also be aware of the scope of industry coverage provided by the available data. Because Class I rail carriers account for about 95 percent of total industry revenues, total-factor productivity measures developed for those carriers account for the bulk of the industry. However, additional productivity data are needed for short-line and regional carriers, which participate in approxi-



Solid Shading = Public Intercity Motor Carriers
Exploded Slices = ICC Reporting Carriers

Figure 1.—Trucking Industry Segments—Share of 1989 Revenue

mately 20 percent of movements. More serious, however, is the lack of productivity data for the trucking industry. Only certain segments of the industry (those that report to ICC) have been studied, and they represent a very thin segment of the industry as a whole (see Figure 1). Yet discussions of productivity in the recent debate over expanded use of longer combination vehicles focused on the these firms. Furthermore, statistics that are available for the entire industry suggest that these firms may not be representative of the industry.

Lawrence echoed Norris' earlier warning that the diversion of traffic from rail to truck can create an overall decline in the country's transportation productivity, even though this diversion may cause modal productivity measures to improve. Trucks compete successfully with rail despite their greater resource consumption because they offer a wider choice of plant locations, they can accommodate small shipment sizes, and they provide other logistical benefits and services. However, these benefits have exacted a high cost in the less efficient use of resources and higher transport costs that put U.S. producers at a disadvantage in the global economy. According to Lawrence, a better balance needs to be achieved. She recommended that the development of intermodal freight transport be promoted under ISTEA so that the United States can take advantage of both modes and increase total productivity.

Experiences in increasing rail productivity offer important lessons for transportation officials, Lawrence maintained. First, productivity indexes can be highly misleading unless they accurately relate the consumption of inputs to the production of outputs, measure and control for the mix of inputs, and measure and control for the mix of outputs. Second, productivity data must cover all of the industry that the analysis is supposed to represent. Productivity measures depend on data availability, and more comprehensive data are badly needed for segments of the transportation industry. Establishing reasonable infrastructure investment priorities depends on better methodology, better coverage, and better data. Finally, the rail experience clearly demonstrates that physical productivity advantages do not guarantee that services will be used. If improved resource use and reduced freight costs are important to economic revitalization, then public policy must support these priorities.

Should Freight Shippers Care About Productivity?

Speaking not as a shipper, but as an advisor to shippers, **Joseph Swanson,** an **Adjunct Professor** at **Northwestern University** and **Managing Director** of **Joseph Swanson & Company,** questioned what the role of the shipper is in the debate over transportation productivity. Swanson first addressed the issue of why a shipper should be concerned with carrier productivity. He then discussed potential methods of measuring productivity in the truckload and LTL segments of the transportation industry. He concluded with reflections on who should be interested in these measurements and on data collection efforts.

Should the shipper be concerned about productivity measures? Although a correct balance between quality and either performance measurements or productivity measurements is unclear, according to Swanson, the shipper must be aware of the issues to make informed decisions. Shippers, as well as public decision-makers, must question which numbers are relevant to accurate measurement of productivity as well as which ones are relevant to performance because a focus on partial productivity measurement systems can lead to serious problems in terms of service quality. Shippers also must consider productivity in cost analyses and in designing long-term contracts.

Swanson maintained that, on the surface, the evaluation of productivity change in the truckload trucking industry appears to be fairly straightforward. The proportions of inputs—the power unit, trailer, load, driver, and fuel—appear to be relatively fixed. However, these appearances belie the sometimes complex considerations that affect labor and capital inputs, such as the number of hours that drivers are allowed to drive in one stretch, or the availability of drivers in certain locations. There is also the dilemma of incorporating and measuring the public inputs of the infrastructure itself. Indeed, usage of such inputs is being maximized by the use of information systems, adjustments to distribution center hours, and alteration of shipment dates to meet distribution center capacity.

The traditional method of measuring productivity changes in the LTL industry, according to Swanson, has been to break the business operations into segments such as pickup and delivery, maintenance, and line haul. This method produced several small, partial productivity measurements for each portion of the service. However, these measurements fail to define the collection of inputs that are put together to accomplish an entire process and therefore give no clear indication of productivity for the LTL industry as a whole. Furthermore, they do not satisfy the shipper's concern about quality service. The shipper is not concerned about particular components of the process, such as pickup and delivery; however, the shipper is concerned when the carrier delivers only a partial shipment of parts or other goods.

Swanson added that some LTL carriers publish rates for certain routes and that he believes these rates reflect long-run marginal costs. Therefore, he suggested that research in this area could be useful, because he believes that there is an exact correspondence between costs and productivity.

Swanson concluded that the primary suppliers of transportation services must continue to measure productivity, even if the reason is merely for competitive analyses. Government also needs to play a significant role in measuring productivity because it can serve as an efficient data collector and compiler of data already existing. Indeed, although many in the rail and trucking industries have vocalized their concerns over additional data collection, Swanson asserted that such an effort would not be as painful or intrusive as many fear.

Discussion

Frank Smith, Executive Consultant for the **Eno Transportation Foundation,** expressed concern that the high financial costs of advanced technology may offset any productivity gains that may be achieved by it, but this fact is largely ignored in the debate. Reduced labor costs achieved in this manner are suspect, as are any other measures, if true operating costs are shown. Perhaps, the participant suggested, there is no such thing as financial productivity in public policy, but this issue is important to businesses because they cannot obtain capital if they do not make money.

Susan Binder, of **FHWA,** pointed out that the airline industry's use of hours of service as a measure of aircraft utilization may also produce misleading information, because it involves only the line-haul portion of the operation (actual inflight time) and does not necessarily adjust for maintenance, loading, unloading, or servicing time. These factors, particularly servicing, must be considered because they are necessary for continued operation. Hyman responded that maintenance characteristics for different types of vehicles vary, but that a formula could be developed to account for such factors. Certainly, flying an airplane until the wings drop off would lead to negative productivity. Binder further suggested that estimations of a similar measure of truck utilization with a maintenance compensation factor would be useful.

Session 4: New Ideas for Measuring Productivity in the Transportation Sector

Development of effective means of measuring productivity is not just an abstract concern, according to the moderator of this session, **Karen Borlaug-Phillips**, a **Commissioner** at **ICC**. Phillips echoed the importance of achieving high levels of production growth in the various segments of the transportation industry because transportation is a major component of the American economy, and productivity is often equated with competitiveness. Because transportation productivity will continue to play a role in major infrastructure investment decisions, progress toward a more effective means of measuring productivity is urgently needed. Meanwhile, specific measures of productivity are being used in other types of decisions made by regulatory agencies. For instance, ICC allows railroads to raise their rates free of ICC interference, using a rail cost adjustment factor that includes a productivity component. The issues discussed in this session on new ideas for measuring productivity in the transportation sector overall have real-world applications, according to Phillips.

The Quality Implications of Transportation Productivity Measures

Reporting on the preliminary quantitative results from productivity and quality analyses that he conducted with John Ozment, Ph.D., of the University of Arkansas, **Edward A. Morash, Ph.D., Professor** of **Business Administration** at **Michigan State University,** addressed major productivity and quality questions using data from the airline industry and from the household goods moving segment of the trucking industry. Morash and Ozment addressed four main research questions:

- To what extent are transportation service quality concepts and measures interrelated?
- To what extent are transportation productivity measures related to service quality measures?
- Are different productivity concepts and measures important in distinguishing productivity-quality relationships?
- Do different types of carriers exhibit varying productivity relationships, and must these relationships be taken into account in productivity investigations?

Morash and Ozment tested both objective and subjective measures of quality, using actual industry figures that represent lapses in quality of service, such as percentage of shipments with loss and damage, percentage of shipments late, etc., as objective measures and customer complaints as a subjective measure. Their results showed that these measures of quality were highly intercorrelated within their respective modes of transportation. These correlations would imply that the many measures used to proxy quality in this case are redundant in an information context. Although some people would argue that the subjective measures are irrelevant because of their relation to idiosyncratic customer behavior, Morash argued that both subjective and objective measures are important in understanding productivity and quality.

Next, Morash and Ozment tested whether firms with greater productivity in terms of network density and capacity utilization also produced higher quality. Results for the airline industry showed that the density of the service-provider network, i.e., frequency of service between two points, had a significant relationship to quality. These results are interesting, according to Morash, because earlier research has shown that networks such as the hub-and-spoke system for airlines or the breakbulk and satellite terminals in trucking also provide cost efficiency. Morash asserted that the better quality carriers have greater productivity in terms of density. Interestingly, they did not find the same type of relationship between quality and capacity utilization; i.e., fully loaded larger planes are not necessarily equated with quality service. However, they found a significant positive relationship between typical managerial productivity measures, such as departures per dollar of assets or revenue per airport, and both subjective and objective quality measures.

Morash and Ozment's analyses support the view that transportation density is associated with lower average total output costs, lower average input costs, higher input yields, and greater asset turnover. Morash added that, if these preliminary results hold, the implication may be that network densities are not only a strategic source of cost advantage but also a basis for quality advantages.

Morash stated that, in light of the airline data correlation analysis, cost efficiency of inputs should not be confused with the productivity of inputs. Indeed, productivity and efficiency are separate concepts that may be traded off against one another. The tests of the airline data found that, although productivity of labor and equipment is associated with higher input costs, productivity is also associated with lower average total output costs and, most interestingly, with higher output quality and revenue yields. In contrast, there is no significant association between greater "efficiency" of labor and equipment input (i.e., low wage rates) and average total output costs; nor is it associated with quality. In some instances in this study, "efficiency" has a significant negative association with quality.

Morash emphasized that the implication of these preliminary tests for the transportation industry is that an exclusive focus on productivity may understate total economies and benefits. Qualitatively different transportation outputs would indicate that physical productivity measures be adjusted upward, possibly by a multiplier effect, to reflect the benefits of both industry and governmental initiatives and partnerships. Morash added that when government provides better infrastructure, it also facilitates quality as an aspect of productivity.

The Relationship Between Increasingly Efficient Highway Freight Transportation Operations and the Improving Productivity of Inventory Investment

The most important measure of highway transportation productivity, according to **Robert V. Delaney, Executive Vice President** of **Cass Logistics, Inc.,** is the ratio of inventory to monthly sales of manufacturing and trade. This measure is the ratio that business understands, and according to Mr. Delaney, transportation officials should focus on this ratio in looking for support for highway expenditures.

Faster, more reliable transport service enables manufacturers to hold less inventory and hold it in fewer warehouses and distribution centers. Inventory rebuilding used to be an indicator of economic recovery, accounting for about one-half of a point of GDP, but this phenomenon is no longer true, according to Delaney. Shipments and expenses both show that the economy is improving, but businesses are not increasing their inventories. Corporate profits are also up, not because of rising prices, but because of reduced investments in inventory assets.

A study by Blinder and Maccini has found that the economy-wide ratio of real inventories to real sales has been trendless for 40 years. Paradoxically, major publications have cited an efficiency in operations and price reductions by businesses. Delaney examined the figures and found that, when deregulation of the transportation industry was beginning to have an impact, the ratio of inventory to sales was 1.52. By March of 1987, the ratio had dropped to 1.28. However, in April of 1987, the Department of Commerce revised the estimation to 1.49 in light of the Tax Reform Act of 1986, thereby retroactively increasing all of the inventory valuations for the previous 5 years. Thus, Delaney concluded that the data in the Blinder and Maccini study was suspect. According to Delaney, increasing the inventory valuations was a mistake that masks the major productivity improvements in the country's highway system.

Although the inventory-sales ratio is currently decreasing, Delaney believes that it is actually lower than public estimations. Furthermore, he asserted that the Bush Administration would have received more support for ISTEA as it originally was written if business leaders possessed a better understanding of the contribution of highways to productivity as reflected in the inventory-sales ratio. Finally, Delaney suggested an interagency task force of representatives from the Departments of Transportation and Commerce and the Antitrust Division of the Department of Justice to examine the data and sort out this situation.

Discussion

W. Bruce Allen, Ph.D., Professor at the **Wharton School, University of Pennsylvania,** cautioned the participants that although Morash's simple correlation analysis is adequate as the authors have conducted it, correlations of measures do not prove causation. The same type of information in a multiple regression analysis might reveal very different results, although multiple regression does not prove causality either. An examination of productivity as a function of the network, utilization, and quality concepts might reveal that productivity and quality are not positively related. Allen also expressed disappointment that the presentation did not use total-factor productivity in its comparisons; however, another speaker soundly criticized the multifactor approach for transportation productivity.

Some aspects of quality cannot be controlled by managers, according to Allen. For example, more flights are canceled at the Hyannis Airport than at the Memphis Airport simply because of the prevalence of fog at the Hyannis Airport. Several factors, such as weather, congested airports, and air traffic control problems, may account for late arrivals.

Allen suggested that productivity measures may be useful to a manager only after the fact. A cost minimization output corresponds to a particular profit maximization quantity. The optimal productivity measure in terms of simple ratios is this profit maximizing output quantity divided by capital. However, it is a mistake, according to Allen, to maximize the output-to-capital ratio. Carried to a ludicrous extreme, pricing at zero maximizes the output produced because everyone wants free goods. However, a manager who acts in this fashion obviously will receive no revenues and will not stay in business.

Allen suggested that more appropriate productivity measures to calculate from a manager's perspective would be the quantity when price equals marginal cost and the most efficient way of producing this output quantity (i.e., quantity-to-input ratios). Allen agreed with Lawrence's earlier remarks that productivity measures must be considered very carefully, and that firms should not be compared unfairly as a result of those measures because they have very different inputs that affect their outputs.

Regarding Delaney's presentation, Allen expressed that, although he believed Delaney's assertions, his academician nature needed more proof than Delaney's anecdotal presentation provided. He also expressed a desire to sort out cause and effect in the changes in ratio of inventory to sales. Because of the contradictions in many of the studies that Delaney cited, Allen questioned if all used the same data sets. He also offered an alternative hypothesis to Delaney's, i.e., that the phenomenon Delaney described is the result of changing interest rates, not of advances in transportation. Either hypothesis could be correct, Allen maintained, and all possible hypotheses should be investigated. In response, Delaney noted that a relationship between inventory investment and interest rates existed between 1959 and 1980. However, following partial deregulation of transportation, Delaney explained, the relationship did not appear to exist.

Session 5: Freight Transportation Productivity Measures

Edwin Dean, Ph.D., Associate Commissioner for Productivity and Technology at BLS, welcomed the participants to this session, which began the second day of the symposium and was moderated by **Elizabeth Pinkston,** an **Economist** with the **Congressional Budget Office**. Dean explained why the widely promulgated transportation productivity growth figure of 0.2 percent is not an official statistic published by BLS. In fact, BLS does not publish any figure for the transportation sector as a whole, but it does maintain a file that combines BEA value-added numbers with U.S. Department of Labor labor-hour figures. Although not published, this file is available on request. However, this file presents a different growth rate depending on the time period selection, and it shows a growth rate greater than 0.2 percent.

BLS does publish two major sets of productivity measures: a labor productivity measure (output per hour) and a multifactor productivity measure (output per unit of combined labor, capital, and intermediate inputs). Included in the publications of labor productivity are (1) quarterly statistics on major sectors of the economy such as total manufacturing; (2) industry statistics for industries whose SIC codes are at the two-, three-, and four-digit levels (including transportation industries); (3) Federal, State, and local governments; and (4) international comparisons between the United States and a number of other countries. The multifactor productivity figures published are statistics on major sectors and detailed industries.

Dean believes that an understanding of productivity measures is relevant in a number of fields for the following activities:

- Assessing the potential for long-term improvement in living standards.
- Evaluating international competitiveness.
- Addressing issues related to inflation.
- Assessing industry performance in discussions of policy for the particular industry.

The lack of detail for industry output measures, resulting from data implications of deregulation in various industries, is a matter of concern to BLS. In fact, BLS has suspended updating of bus and trucking statistics because, since 1989, the data on detailed outputs is insufficient and unreliable. BLS is interested in obtaining more detailed information, without enacting further regulation, regarding characteristics of particular types of ton-miles, passenger miles, or revenue statistics, which may serve as indicators of changes in the composition of output. By gathering this information, BLS can adjust productivity measures for the changes in output composition.

BLS is in tune with DOT, ICC, the Census Bureau, and other agencies in their desire to obtain and publish more detail in physical units and in their use of indicators of changes in composition. Dean cautioned that the agencies should work together to avoid duplicating one another's efforts. BLS welcomes the opportunity to cooperate with other agencies in these efforts.

Freight Transportation Productivity Measures

If one accepts the results of one index of multifactor productivity, asserted **Thomas Corsi, Ph.D., Professor** and **Chairperson** of **Transportation, Business, and Public Policy** at the **University of Maryland,** the Motor Carrier Act of 1980 resulted in a slowdown in productivity growth in the industry instead of an enhancement of efficiency. Corsi cited a study conducted by Robert Gordon and published by the National Bureau of Economic Research, which calculates a revised index of multifactor productivity. This study indicates average annual increases for the motor carrier industry of 1.47 percent between 1959 and 1969, 2.36 percent between 1969 and 1978, and less than 1 percent between 1978 and 1987. The decline in the latter period occurred during the years of administrative deregulation at ICC and the first years of the Motor Carrier Act. However, the decline does not parallel observed advancements in many areas of the motor carrier industry.

Multifactor productivity measures are highly sensitive to the specific inputs and outputs selected and to the weights given to each of these measures. However, there are no clear indications about the individual contributions of each measure. The use of different indicators and alternative weights could result in substantially different conclusions, according to Corsi.

Instead of multifactor productivity measures, the motor carrier industry uses three individual indicators of performance efficiency:

- Annual miles per truck.
- Average load (derived from ton-miles over total vehicle miles).
- Average length of haul.

Significant changes in these measures occurred between 1977 and 1987, according to published annual report data from Class I and Class II motor carriers. The average annual miles per truck increased from 53,900 to 65,700 miles (86,741 to 105,731 kilometers). These increases were most significant in the LTL and truckload general freight segments. The average load increased from 11.6 to 13.1 tons (10.5 to 11.9 megagrams). These increases were most significant for truckload general freight and other specialized commodity segments and were primarily the result of increases in vehicle sizes and weights. The average length of haul increased from 280 to 380 miles (450 to 611 kilometers). This overall result held true for the LTL and truckload general freight segments. These increases stemmed from new flexibility allowed the truckers in choosing the geographic territories they serve.

Two dynamic changes in the trucking industry are not apparent in these performance statistics. First is the increase in carriers' use of owner/operators, which offer significant advantages over the use of company drivers. Owner/operators averaged 80,200 miles (129,066 kilometers) per truck in 1987, compared to an industry average of 65,000 miles (104,605 kilometers) per truck; their average load was 14.2 tons (12.9 megagrams) versus the industry average of 13 tons (11.8 megagrams); and their average length of haul was 493 miles (793 kilometers), compared to 380 miles (612 kilometers) for all Class I and Class II carriers combined.

Second, the industry experienced significant gains among advanced truckload freight (ATLF) carriers, who concentrate on long-haul traffic in high-density traffic corridors. ATLF carriers have a distinct management approach that allows them to operate with lower costs. They use company drivers, who are more productive, reliable, and safety conscious. Carriers often assign these drivers in teams so that trucks can operate more hours per day, resulting in significant increases in annual tractor mileage. Their focus on safety has enabled many of them to lower their insurance premiums, thereby lowering costs. They also offer sophisticated load-matching capabilities. The results of these practices are more than 100,000 annual miles (160,930 kilometers) per truck, an average load of 16.3 tons (14.8 megagrams), and an average length of haul of 1,232 miles (1,983 kilometers).

These figures clearly demonstrate that the motor carrier industry has achieved a significantly greater level of efficiency than that indicated by multifactor productivity measures, Corsi stated, as he again questioned the inputs and outputs used and weights given to each in the index. He noted that operating expenses for Class I and II carriers combined decreased more than 30 percent in real terms from 1977 to 1987. He further emphasized that the multifactor productivity index shows effects of a broad category of trucking firms of various sizes, and he is uncertain that these measures truly reflect this composition. He advised using individual measures of motor carrier efficiency or performance to determine productivity. He expressed concern, however, about the lack of data available and the low level of reporting requirements for individual firms. He recommended collecting the following additional measures:

- **Route-miles.** This type of data was collected by ICC before deregulation, when carriers were allowed to travel only on certain highways. However, it is still viable in the deregulated environment, according to Corsi. A route-mile total could be calculated for a carrier, using available network algorithms based on the geographic location of each terminal and the terminal-to-terminal linkages. This measure would give an indication of changes in density.

- **Number of terminals.** A picture of terminal performance could be gained by dividing total tons or shipments by the number of terminals. Firms could then be compared based on terminal performance.

- **Percentage of empty vehicle-miles.** A significant advantage of advanced truckload carriers is their ability to reduce empty vehicle-miles. Measuring the percentage of empty vehicle-miles would capture this improvement in efficiency, which is not captured in multifactor productivity measures.

Availability of this type of data would facilitate the more systematic, comprehensive analysis that is needed to assess the impact of legislation on the motor carrier industry and efforts by the motor carriers themselves to improve efficiency.

Any discussion of industry efficiency or productivity must also recognize the changes in services provided since deregulation occurred. Shippers have placed increasing demands on carriers for specific delivery dates and times to meet the requirements of their just-in-time inventory and production systems. To ensure that these needs are met, shippers have developed closer long-term relationships, or "partnershipping" agreements, with carriers. Carriers have been forced to change their operating systems in response to these demands for enhanced service quality. One result is the significant increase in on-time performance in the industry. This type of environment contrasts sharply with the regulated environment, in which a shipper's ability to give incentives for superior performance or penalties for failures was countered by regulations against discrimination or preferential treatment.

Increased emphasis on safety is another factor that must be considered. The number of trucks being inspected and the level of inspections have increased significantly, beginning with the Motor Carrier Assistance Program in 1982. Carriers must now deliver the goods not only on time but also with an established safety record achieved as a result of a comprehensive risk-management program.

Output in the motor carrier industry is no longer simply movement of goods from point A to point B. The emphasis on safety and transit time changes the quality of output substantially; transit time and real operating costs, or expenses per mile, have been significantly reduced while safety performance has improved, yielding a higher quality output. Thus, efficiency and productivity comparisons have become extremely difficult. It is clear that additional measures are needed to improve understanding of productivity in the industry. Corsi maintained that collection of data on the measures he recommended—route miles, number of terminals, and percentage of empty vehicle-miles—would be an important first step in improving productivity measures.

Current Treatment of Transportation Productivity Measures by the Bureau of Labor Statistics

Transportation productivity measures form just one part of a broad program of measurement encompassing labor and multifactor measures, explained **John Duke**, a **Supervisory Economist** with **BLS's Office of Productivity and Technology**. BLS presently publishes labor productivity statistics on the following five industries in the transportation sector: Class I railroads; Class I bus carriers; Class I and Class II trucking firms, excluding local trucking; air transportation; and petroleum pipelines. In 1980, these industries represented 50 percent of transportation employment, but because of declines in employment in certain industries, most notably railroads, they now represent approximately 37 percent of total transportation employment.

Labor productivity measures are computed as indexes of output per hour by dividing an index of output by an index of aggregate employee hours. This labor productivity index eliminates the effects of shifts in product mix on the productivity index. The basic unit of output is the ton-mile for freight transportation and the passenger-mile for transport of persons. Although detailed data are not collected to account for the different characteristics of these outputs, BLS uses all of the data that are available. The indexes of employee hours are computed by dividing aggregate employee hours for each year by the base period aggregate. Because of data limitations, these hours are treated as homogenous, with no distinction for changes in qualitative aspects such as skill and experience. BLS uses a slightly different methodology for collecting data and computing these statistics for each industry. For industries such as trucking, for which good data on average hours per worker are nonexistent, labor input is represented by an index of the number of employees.

The transportation industries for which BLS publishes labor productivity statistics exhibit widely varying labor productivity trends, as shown

Table 6.—Labor Productivity Growth in Transportation Industries (compound average annual rates of change in percent)

Transportation Industry	1960–89	1960–73	1973–79	1979–89
Railroads SIC 4011	5.9	6.0	1.4	8.7
Bus carriers, Class I SIC 411, 413,414 (part)	0.0	0.8	-1.3	-0.3
Trucking, except local SIC 4213 (part)	2.9	2.9	3.2	2.7
Air transportation SIC 4512, 4513, 4522 (part)	4.9	7.3	4.8	1.8
Petroleum pipelines SIC 4612, 4613	4.3	8.8	0.6	0.7

Source: Bureau of Labor Statistics

in Table 6. From 1960 to 1989, the average annual growth rate was 5.9 percent for railroads, zero for bus carriers, 2.9 percent for trucking (except local), 4.9 percent for airlines, and 4.3 percent for petroleum pipelines. However, most of these industries show evidence of the general slowdown in productivity growth that was pervasive throughout the economy in the 1970's. In the 1980's, when many industries experienced rebounding productivity growth, the record for transportation was somewhat mixed. Only railroads, which rebounded from a 1.4 percent productivity growth rate in the 1970's to 8.7 percent in the 1980's, showed strong productivity growth, according to BLS labor productivity measures.

Duke briefly explained the methodology behind some of the industry-specific calculations, emphasizing BLS's attempt to adjust for underlying service differences of various quantities of output. An index of commodity mix is calculated and used as an adjustment factor to reflect differences in service characteristics. In modes such as rail, passenger-miles and ton-miles are combined using labor expenses as weights. For trucking, BLS labor productivity measures cover only Class I and II carriers. With the use of employment data as weights, ton-mile output is aggregated for three major carrier groups: general freight, specialized carriers, and household goods carriers. The labor input measure used in the trucking sector is number of employees because available data on hours are insufficient.

The major limitation of these labor productivity measures is the lack of detail on outputs in many cases. Although BLS takes advantage of as much data as possible in developing its measures, the lack of data on output composition prevents the figures from fully reflecting varying service characteristics. Furthermore, BLS has encountered serious problems in collecting data for trucking and bus carriers. Data filed by motor carriers with ICC and aggregated by the American Trucking Associations are often filed late and may be incomplete or inconsistent. Because of these problems, not all Class I and Class II carriers are included in the industry totals, making year-to-year comparability of the data a concern. Duke maintained that a government agency should take responsibility for the difficult tasks of collecting, editing, and aggregating the data to ensure that the data are adequate. He further recommended that Class III trucking firms be included in the data collected, because these firms are so numerous. Similar problems with the collection of data from bus carriers have caused BLS to stop updating this measure until better data can be obtained.

Multifactor productivity measures produced by BLS first covered the major sectors of the economy. However, recent efforts have been directed at the industry level so that these statistics are now available for all two-digit SIC categories in manufacturing and for six industries in the three- and four-digit categories. Because of the complexity of the data necessary to calculate multifactor productivity measures, few three- or four-digit industries boast BLS multifactor productivity measures. However, the latest three- and four-digit measures are for railroads.

The methodology for multifactor productivity measures begins with a production function that considers output as a function of capital, labor, intermediate inputs, and time. The rate of growth is equal to the growth rate of output minus the growth rates in each of the inputs, which are weighted by their cost shares in the total cost of production. Intermediate inputs are important in this equation because they can be substituted for capital and labor in a firm's production decisions.

In computing multifactor productivity for railroads, BLS used an aggregation of weighted freight ton-miles and passenger miles for the output measure. BLS used waybill sample statistics on proportions of ton-miles and revenue, adjusted for length of haul, commodity, and shipping mode to allow for differing service characteristics for different types of shipments. Four hundred categories are used, grouped by 4 ranges of length of haul, 50 commodity types, and 2 shipping modes. Ton-miles in each category are aggregated using revenue shares. The employee-hour index measures the change in employee hours over time, with adjustments to exclude capitalized labor, which is included in investment expenditures as part of the capital input. The capital input index is based on the flow of services from the stock of physical assets. Capital stock of equipment and structures are calculated from investment data obtained from ICC and are deflated to constant dollars using BEA and BLS data. The real value of inventories and an estimate of land stocks are included as part of the capital input. Capital inputs are aggregated with cost shares based on implicit rental prices. The input of intermediate purchases includes materials, fuel, electricity, and services; data from ICC and the Association of American Railroads are used for these measures. The index of combined inputs is calculated as an aggregate of the input indexes of labor hours, capital, and intermediate purchases.

The results show that multifactor productivity in railroad transportation grew at an average annual rate of 4.0 percent from 1960 to 1989. Broken into subperiods, the average annual rates were 4.7 percent for 1960 to 1973, 1.2 percent for 1973 to 1979, and 4.8 percent for 1979 to 1989. Thus, the productivity statistics for railroads show that both multifactor productivity and labor productivity experienced a slowdown in the 1970's.

In closing, Duke reported that BLS is currently working on a multifactor productivity measure for airlines and hopes to publish estimates in late 1993. BLS is also studying the feasibility of producing a multifactor productivity measure for trucking; however, Duke urged that problems with the collection and aggregation of data for both the trucking and the bus carrier industries must be resolved as soon as possible so that better measures may be developed.

Discussion

Several questions arose about the methodology and adequacy of various weighting and adjustment schemes. Both Duke and Dean attempted to clarify instances where BLS is trying to adjust for shifts in composition of the output measure. In the labor productivity measure, BLS must aggregate different products to an industry level, explained Dean, and it has chosen labor requirements for each product as its weighting unit. To illustrate how BLS eliminates the effects of changing output mixes on productivity, he described a case in which an industry has two products with no change in service characteristics or quality. In the base year, the first product represented 40 percent of the output, and the second product was 60 percent of the output. In the next year, the share of output for each product was reversed. If the product that represented the greater weight in product mix during the second year also had greater unit labor requirements, a decrease in the productivity measure would result, not because of falling efficiency, but because of the shift in output composition. Thus, BLS attempts to reflect the effect on the total of a shift between two types of output by applying labor requirement weights to each product to prevent these shifts from biasing the productivity measure. When detailed labor requirements data are unavailable, BLS uses unit revenue weights based on the prices charged for the different types of outputs. When quality changes in output are a significant issue, BLS measures output in constant dollars by dividing the value of each product by a price index that has been adjusted, whenever possible, to reflect the quality change. If prices decrease across the board, quality change is not underestimated because the technique uses relative prices of each of the different components at each comparison period. The key concern is the relative importance of each component, not changes in input costs over time. **Arthur Jacoby**, of **FHWA**, postulated that, by using a base-year unit revenue value as an adjustment factor for quality changes, BLS multifactor productivity measures may be building in a bias to the productivity measures if, for instance, there is a shift toward longer distance transports.

Presentation of Breakout Findings

Breakout Group A: Applications of Transportation Productivity Measures and Research Recommendations

Group A focused on various applications of transportation productivity measures in terms of users' purposes. Chairperson **Daniel Brod, Principal** at the **Hickling Corporation,** suggested that the "measurement of transportation productivity is to see what it contributes to GNP growth." A participant noted that many shippers and truckers wish a Government agency would develop a model that measures an entire profit center, not just little pieces of the center.

Responding to its first assignment, the group brainstormed the following applications of productivity measures:

- Business planning and tracking, which helps the private sector make prudent decisions.
- The basis for decisions regarding government infrastructure investment policy and programs.
- Private sector investment, i.e., the best use of the dollar.
- An evaluation tool for public policy.

During this brainstorming exercise, one participant commented that current productivity measures aren't adequate for the private sector—the people "running the road." Another person suggested that there is a move toward less comprehensive data; that person wondered aloud if the new Administration will bring the desire for "richer, fuller data."

That comment, the chairperson pointed out, was a natural segue into Group A's next assignment, which it interpreted as the need to develop a list of indicators that could be used to generate meaningful, credible transportation productivity measures.

Empty versus loaded miles was the first of a number of alternative indicators mentioned. One participant who has a background in the trucking industry said that truck companies don't care about the standard indicator, ton-miles. He added that a truck not carrying its full freight is much less productive than a truck carrying full freight.

The next two indicators—annual vehicle-miles per truck and the average length of haul by vehicle—were suggested almost in one breath and accepted without discussion. A participant involved in economic analysis suggested that revenue per ton-mile was a needed indicator. She pointed out that this indicator should not be confused with value of goods shipped; the revenue from a load of diamonds, she explained, would be far different than the revenue from a load of sand. Another participant said that commodity value per ton-mile is likewise important data to capture and consider. This indicator was described as the difference between the productiveness of coal moving along tracks versus a shipment of computers moving along the highways. (Commodity value is important when considering the relationship between freight transport and inventories. Freight-in-transit represents inventories in the order pipeline and an important measure of the "productiveness" of freight transport is its impact on the dollar value of inventories, of which pipeline inventory is but one type.)

The final two indicators listed were energy consumption per ton-mile and labor cost per ton-mile. Concerning the former, a group member said that this indicator "had been quiescent but will appear on the screen" in the not too distant future. He considered the use of this indicator long overdue and recommended seeing if any data were available for it. Labor cost per ton-mile was described basically as the time savings considered in cost-benefit analyses. Another participant remarked that value-added services are innovations that trucking companies have made to improve labor cost per ton-mile.

With these two lists in hand, the group devised the matrix shown in Table 7, rating the utility of each indicator for every application. (However, these ratings do not indicate availability of data.)

Table 7.—Utility of Proposed Indicators for Applications of Productivity Measures

Indicators	Applications: Business Planning	Government Infrastructure	Private Sector Investment	Public Policy Evaluation
Empty vs. loaded miles	Good	Good	Good	Good
Vehicle miles per truck	Good	Fair	Good	Fair
Average length of haul	Good	Fair	Good	Good
Revenue per ton-mile	Good	Fair	Good	Fair
Commodity value per ton-mile	Good	Fair to Good	Good	Fair
Energy consumption per ton-mile	Fair	Good	Fair	Good
Labor cost per ton-mile	Good	Fair	Good	Fair

Table 7 shows that empty versus loaded miles received the highest utility ranking. Commodity value per ton-mile and average length of haul were the next best indicators. One person characterized this exercise as "having the eggs, milk, and butter that go into the cake; now we're interested in the cake." As the exercise progressed, another participant pointed out that his colleagues continued to question the availability of data for this richer data set that the group seemed to indicate was desired. For most indicators, rating its utility to government infrastructure decisions generated the most discussion. Group A concluded that they had developed a list of measures that are very important to truckers and other transportation modes but not very important to public policy.

In the second work group session, Group A identified the following issues regarding data:

Are data representative? The group debated if available data constitute a representative, good, and unbiased sample or if new sampling methods are needed. Members identified the ICC sampling as one gap between what is needed and what is available, explaining that this sampling does not include anything that is self shipped. Other members pointed out that current measures may have been good for rate-making but are not good for other applications, such as business planning or private-sector investment.

Are data complete? Participants were concerned about whether available data are complete enough to give a picture of what government and business are interested in today. One person related that much of ICC data, including "just about all" of the measures on the group's list, were lost through deregulation. Carriers continued to provide the raw data—all Class I railroads and Class I and II carriers are required to provide these data—but the Commission is not manipulating them into useful information. It was suggested that there may be different levels of aggregation and summation that would serve this group's understanding of completeness.

Do data take full advantage of today's technology? There is an abundance of technology marketed today for identifying, analyzing, and sharing data. Group A briefly considered if this technology is being used to its full advantage, but no consensus was reached.

How are data related to the Nation's economy? This discussion built on the chairperson's opening remarks about how transportation productivity contributes to GNP growth. Participants commented that it is important to know whether the effects of changes in transportation on productivity are being studied as a whole or as their effect on the Nation's economy.

Finally, the group developed the following research recommendations by first reviewing the issues they had just identified. They offered three recommendations; members did not consider the issue of technical advantage a current research priority.

Inventory data and productivity measures. Determine areas or interests covered as well as the data's value, usefulness, and shortcomings. This inventory, the group maintained, would identify gaps and resource needs. Because of the scope of this undertaking, which would take into account old and lost data, the idea of doing the inventory raised a couple of questions. How much would gathering the data cost? Can the data be accessed?

Investigate network productivity effects. This study would consider intermodal connections and should explore the effects on national, state, local, and international systems. Effects on international systems are particularly important now that the North American Free Trade Agreement is a leading issue on most priority lists.

Research the implications of transportation improvements on economic productivity in other sectors. This research recommendation was offered as a way to see "the big picture."

Breakout Group B: Key Issues and Data Collection Needs By Mode and Scale

This breakout group, chaired by **Susan Binder, Chief** of the **Industry and Economic Analysis Branch** in the **Office of Policy Development** at **FHWA**, discussed the following topics: issues that must be addressed to generate meaningful, credible transportation productivity measures; various scales at which transportation productivity measures are applied; and gaps in the available data.

The group identified the following issues, listed in priority order, that must be addressed in developing productivity measures:

The importance of identifying key questions. The key questions that productivity measures are designed to answer must be identified before decisions can be made on what data to collect. Different segments of the industry and different disciplines have different issues to be addressed and therefore different questions to be answered. The questions will also yield different answers depending on the application and the users. The questions should also be prioritized so that the most urgent data needs are met. There is a virtuous circle in this process because when the questions are identified, the measures are designed with an eye to what data are necessary and available. The process leads ultimately to a multipurpose database rather than specific measures.

The relevance of efficiency measures. Even though efficiency measures are not necessarily productivity measures, their relevance makes them an issue that has to be tackled. Although the group members agreed that efficiency measures give a sense of change and of scale, they disagreed about the relationship between efficiency and productivity. They questioned whether productivity measures are a summation of efficiency increases.

The lack of disaggregate data. Because transportation industries are multiproduct industries, a single aggregate measure is not sufficient. Detailed data should be collected by mode and by different output characteristics, such as freight versus passenger. Detail is required, not only for aggregation purposes but also for application purposes. Aggregate data do not necessarily show the whole picture.

The uncertainty regarding the availability of data. Information sharing and cooperation are needed among agencies to determine sources of data. A thorough inventory of available data would be useful.

The urgency of deciding what data to collect. These decisions require assessing cost and other practical issues. The data to be collected depends on the questions to be answered; the data must also address different purposes and needs of data users. Once a consensus is reached on what data to collect, methods of collecting the data must be explored. The cost and practicality of different collection methods must be compared.

The group members agreed that all five issues involve avoiding inaccurate interpretation of the data regarding any one industry. The group then identified the following scales, or application levels, at which transportation productivity measures may be applied:

- Corporate-level
- Industry-level
- National
- International or multinational
- Regional, multi-State, or sub-State
- State
- Metropolitan area
- Facility-based. Facilities are usually controlled by an entity that has data that can be used in assessing productivity.

Table 8.—Data Gaps by Transportation Mode and Scale

	Mode									
						Long Distance Transit				
Scale	Air	Railroads (freight)	Pipelines	Marine	Waterway	Railroads (passengerr)	Bus	Local Transit	Truck	Intermodal
Corporate	♦♦	♦♦	♦♦	♦♦	♦♦	♦♦	♦♦	♦♦	♦♦	♦♦
Industry Level	♦♦	♦	♦♦	♦	♦	♦		♦♦	♦	♦♦
National	♦♦	♦♦	♦♦	♦	♦	♦		♦♦	♦	♦♦
Int'l	♦♦	—	♦♦	♦♦	—	♦		—	?	♦♦
Regional	♦♦	♦	♦♦		♦	♦		—		♦♦
State	♦♦	♦	♦♦	—	♦	♦		♦♦		♦♦
Metro	♦		♦♦	—	♦	♦		♦♦		—
Facility-based	♦♦	♦♦	♦♦	♦♦	♦	♦		♦♦	♦♦	♦♦

♦♦ = Abundant Data ♦ = Partial Data [blank] = No Data — = Not Applicable

Transportation measures currently calculated that the group identified include corporate productivity measures as well as measures based on the following transportation modes: air, rail, pipeline, coastal marine, inland waterways, long-distance transit, local transit, trucking, and intermodal. Productivity measures could also be categorized according to the type of services they offer (freight or passenger), the type of capital investments, the markets served, whether the transportation service is provided by the public or the private sector, and ownership. The group then developed a matrix identifying gaps in data based on transportation modes. The matrix is shown in Table 8.

Each mode has its own characteristics, as outlined below:

- **Air.** The aviation industry is far more data intensive than other transportation industries. It matured in the information age and has always been a regulated industry. There is a limited number of players, but they are large and sophisticated.
- **Railroads (freight).** A large amount of data are collected on railroads, but some of the data is not particularly useful. The data collected is primarily for Class I carriers, with very little for the other classes. The facilities collect data, but the data are not readily available.
- **Pipelines.** Pipelines are highly regulated and data are available. Also, this industry does not change very quickly.
- **Waterways.** This industry involves the movement of goods on inland waterways. It is governed by the Jones Act and recorded by the Corps of Engineers. They take information on all physical characteristics, but there is no carrier-specific information.
- **Long Distance Transit.** The section should be divided into passenger rail (Amtrak) and bus. Amtrak has data, but the data are not available. There is not much data on buses.
- **Local Transit.** This mode could be divided into components. Any local transit operation that receives Federal funding must report under Section 15, so eventually there should be good data at the national level.
- **Trucking.** Only partial data exist for industry segments and at the national level. Much

of the data collected by facilities are not available to the public or Government. Complete coverage and detailed data are needed for private trucking operations performed by other establishments not included in the transportation industry (such as retailers).

- **Intermodal.** The overall multimodal system productivity measures are minimal at best.

Some group members questioned whether automobiles should be in the matrix. Others argued that, although automobiles are a method of transportation, they do not constitute an industry because they are consumptive rather than productive. Therefore, the group agreed that they should not be in the matrix.

In preparing the matrix, the group identified several issues for further discussion. First, they maintained that the trucking industry sees itself as a potential target; it is discriminated against for its use of infrastructure and is used as a source of funding. The most important improvement related to productivity measures, from the truckers' viewpoint, would be to improve public understanding of the role that trucking plays in economic growth.

The group pointed out that each category of the matrix should be researched systematically and comprehensively. At least some data exist for every category, but computing productivity accurately with little or no data is impossible. The participants recommended obtaining information from at least one company in each modal category so that preliminary calculations can be done. However, they cautioned against overburdening respondents with requests for too much data. The waybill sample is a good source of data, according to the group, because it provides a great deal of data. The ideal way to gather data is to carefully design disaggregate efforts that can be expanded to a national level. Data collection should be structured as a database rather than a sample, and any information that may be needed for future use should be included.

One member of the group pointed out that the discussion has involved two categories of information: (1) what the economists call productivity data, which is detailed quantity and price data, and (2) all other measures (such as performance data) that are important to businesses. He suggested that both types of information be collected in the same report.

Another person proposed that the new Bureau of Transportation Statistics should design a series of 15 or 20 major sample frames with disaggregate sampling methodology that would form a multipurpose database.

Breakout Group C: Merits of Transportation Productivity Measures and Barriers to More Meaningful Measurement

The Group C breakout session, chaired by **Stephen Thompson**, a **Specialist in Transportation** at the **Congressional Research Service**, took a different tack from the other two breakout groups. Group members adopted a "brainstorming" format, working on a number of ideas simultaneously.

The group began by debating the merits of productivity measures: how useful are they as an overall measure? What do they tell evaluators and what do they omit? Are there other, more meaningful measures (e.g., private sector performance and transportation system performance indicators) that should be used to evaluate the transportation industry? Issues such as quality, safety, reliability, environmental cost, and economic cost probably ought to be reflected in any meaningful measurement. Theoretically, these items could be combined in a vector to generate a single number, but its utility might well be limited. After several abortive attempts, the group came to the consensus that it is virtually impossible to build a matrix or typology of measures based on their characteristics that would be sophisticated enough to cover the entire transportation industry.

Group members also discussed the thinking behind productivity measures and the reasons that such measures were developed. Data on transportation industry productivity are used by several groups of consumers, including those who collect the data (collectors), those who interpret the data (manipulators), and those who ultimately use the data (users). All of these groups have a public policy orientation. On the other hand, the private sector relies more upon performance data than generalized productivity data.

Group members, most of whom work in the public policy arena, expressed concern about the validity of productivity and other types of measures currently being estimated. It was noted that large, aggregate measures often fail to detect significant details or subtle shifts in an industry. In general, there needs to be greater interaction between the questions being asked and the data being collected. Clearly, the more comprehensive the coverage and the more accurate the reporting, the more useful the data become to policymakers. Common sense analysis is obviously also required. The group discussed whether "bad" data are worse than no data; it was decided that even "bad" data can be useful in highlighting improvements that need to be made.

The group also explored future directions for data collection and analysis. It is expected that improving technology will allow cheaper and better data collection, as well as easier access to data already collected. The availability of financial resources to collect data is of some concern. Group members noted that increased data collection may impose reporting burdens on the industry. Several group members expressed a preference for using sampling or estimation techniques, rather than census-style techniques, for data collection. It was suggested that cost-benefit analyses be undertaken to evaluate current methods of data collection, analysis, and reporting, including productivity measures. Finally, it was noted that the growth of the European Community into the largest market in the world may have a profound impact on the U.S. transportation industry and specifically upon its data collection needs and capabilities.

The breakout group identified the following research barriers that may impede meaningful analysis of the transportation industry:

- Data currently being collected do not cover important parts of the transportation industry, including pedestrian and bicycle traffic and private trucking.
- Better data would be useful for several other sectors of the industry, including buses and Class II trucking.
- Proprietary concerns may impede data collection; for-hire trucking firms may not want to share their data with outside entities.
- The philosophical outlook toward data collection varies from time to time at the Federal level, depending on the political party currently in power and other factors.
- Fewer Federal research dollars may be available for data collection in the future, necessitating more efficient data collection and analysis.

It was suggested that DOT coordinate closely with BLS, ICC, and the Census Bureau to avoid duplication in data gathering and publication and to improve data gathering methodology. Group members expressed concern that their deliberations lacked input from all types of data users and thus may have been deficient from that perspective.

Conclusion

This symposium provided the important preliminary steps needed in resolving current issues in transportation productivity measurement by generating several points of consensus among the participants. The presentations offered many participants a broader understanding of traditional productivity measures and highlighted potential benefits of industry performance and efficiency measures. In particular, the presentations underscored the dearth of available data that can contribute to meaningful productivity measurements. Participants agreed that the work necessary to provide more meaningful measures of transportation productivity, especially for highway-related industries, is far from complete.

Productivity measures suited to one transportation sector may have no real application in another sector, and the key issues and data needs for each mode are unique. However, all the modes face similar challenges to better productivity measurement. Although this symposium answered several questions, an equal number were raised that need to be answered to effectively address all of the issues. For example, presenters raised questions about how the restructuring of transportation industries brought about by deregulation can be accounted for in interpretations of productivity. Concerns also arose regarding whether and how factors such as improved safety and reliability, just-in-time inventory procedures, and shorter transit time can be incorporated into productivity measurement. In the breakout groups, participants addressed topics that are fundamental to resolving these issues: What are the objectives in measuring transportation productivity, and what results are expected to be derived from the measurements? How should productivity measurements be used? How can current productivity measurements be best adapted to reflect the characteristics of service industries? The breakout discussions emphasized identifying the most important issues, the merits of productivity measurement, and barriers to improved estimation.

Specific questions arose at the symposium about which measures would be most valuable to calculate:

- Productivity or productive efficiency?
- Efficiency or effectiveness?
- Productivity or performance?
- Transportation industry or firm efficiency or efficiency for the consumer?
- Single factor or total factor productivity measures?

Opinions about which measures should be calculated varied according to the prospective use and user. Thus, the participants agreed that business planners, public policy analysts, and private-sector investors might find some measures more useful than others. One person suggested that performance measures for highway transportation could be improved by the collection of additional data on route-miles, the number of terminals, and the number of empty vehicle-miles. Many participants concurred with a cited study showing that, to avoid underestimating productivity, quality effects must be considered. Participants also emphasized the greater value of total factor productivity measures, noting their usefulness, as opposed to single factor measures.

Participants identified several issues regarding data requirements for generating meaningful transportation productivity measures. They stressed the need for acquiring more complete and representative data and the urgency of identifying key questions for each group of data users. The attendees also discussed the implementation of modern data collection technology and the usefulness of sampling and estimation techniques. Although the group expressed concern about the portions of the transportation sector that have little or no data collected, they cautioned that reporting burdens placed on private industry must be minimized as agencies try to meet the demands for disaggregate modal data.

Several attendees also emphasized caution when interpreting productivity measures. It is important, for instance, to distinguish between productivity growth of the general economy as a result of increased investment in transportation and productivity growth in the transportation sector itself. Furthermore, traditional measures of productivity may be incomplete, especially when the measures are used for a variety of purposes. For some uses, the attendees suggested, it may be best to expand upon the traditional productivity measures and include indicators of performance. Many people acknowledged that, to acquire complete measurements, the objectives must first be clarified.

Many participants agreed that additional input is needed from other members of the private transportation industry, specifically from firms that may gather and analyze their own data. They also stressed the importance of coordination among the various government agencies, trade associations, and private-sector firms. Nevertheless, this symposium has opened lines of communication, and FHWA commends the participants, presenters, panelists, moderators, and facilitators for their active participation. FHWA also looks forward to a continued open exchange of ideas to achieve improvements in the measurement of transportation productivity.

Appendix A: Participants

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Appendix B: Agenda

November 19–20, 1992
Stouffer Concourse Hotel, Arlington, Virginia

Thursday, November 19

7:30 am	**Registration**
8:30 am	**Welcome and Opening Remarks** Madeleine Bloom, Office of Policy Development, Federal Highway Administration, U.S. Department of Transportation
8:45 am	**Session 1: The Importance of Correctly Measuring Transportation Productivity in a Changing Environment** *Moderator:* Robert Knisely, Bureau of Transportation Statistics, U.S. Department of Transportation Changing Economics of the 1990's Eric Beshers, Apogee Research, Inc. The Transportation Industry Moves America: Freight and Passengers Dr. Bahar Norris, Volpe Center, U.S. Department of Transportation Transportation's Role in Economic Performance Dr. Randall Eberts, Federal Reserve Bank of Cleveland Issues in Meaningful Measurement Paula Young, U.S. Department of Commerce *Discussants* Lester Lamm, Highway Users Federation Paul Roberts, Transmode Consultants
11:00 am	**Break**
11:15 am	**Session 2: An Introduction to Transportation Productivity Measures** Alan Pisarski, Consultant
12:00 noon	**Luncheon** Tim Lynch, Roadway Services, Inc.
1:15 pm	**Session 3: Modal Freight Productivity Panel Discussion** *Moderator:* Alan Pisarski, Consultant Airline—Paul Hyman, Air Transport Association Rail—Martha Lawrence, Transport & Management Consultants, Inc. Shipper—Joseph Swanson, Joseph Swanson & Co. and Kellogg Graduate School of Management at Northwestern University
2:30 pm	**Break**

2:45 pm	**Session 4: Productivity in the Transportation Sector** *Moderator:* Karen Borlaug-Phillips, Interstate Commerce Commission The Quality Implications of Transportation Productivity Measures Dr. Edward Morash, Michigan State University Dr. John Ozment, University of Arkansas The Relationship Between Increasingly Efficient Highway Freight Transportation Operations and the Improving Productivity of Inventory Investment Robert Delaney, Cass Logistics, Inc. *Discussant* Dr. Bruce Allen, University of Pennsylvania
4:00 pm	**Wrap-up Session, Brief Discussion of Questions To Be Addressed in the Technical Problem Solving Session** Alan Pisarski, Consultant

Friday, November 20

7:30 am	**Registration**
8:30 am	**Welcome** Edwin Dean, Office of Productivity and Technology, U.S. Department of Labor Brief Re-cap of Day One and Charge for Day Two Alan Pisarski, Consultant
8:45 am	**Session 5: Freight Transportation Productivity Measures** *Moderator:* Elizabeth Pinkston, Congressional Budget Office Freight Transportation Performance Measures Dr. Thomas Corsi, University of Maryland Current Treatment of Transportation Productivity Measures by the Bureau of Labor Statistics John Duke, Bureau of Labor Statistics, U.S. Department of Labor
10:15 am	**Break**
10:30 am	**Breakout Session I: Where Do We Go From Here?** Brainstorming and Technical Problem Solving
12:00 noon	**Lunch**
1:00 pm	**Breakout Session II: Research Goals and Data Needs** Research Recommendations and Presentation Preparation
2:30 pm	**Presentation of Breakout Findings** Group A—Daniel Brod, Hickling Corporation Group B—Susan Binder, Federal Highway Administration, U.S. Department of Transportation Group C—Stephen Thompson, Congressional Research Service
3:00 pm	**Discussion**
3:30 pm	**Closing Remarks**
Adjourn	

Appendix C: Additional Tables

The following tables, presented in Session 1 of the symposium, are drawn from BEA's input-output accounts, which integrate data from a variety of sources to show the production of commodities (goods and services) by industry (Table C1) and the use of commodities by industry (Table C2).

Table C1.—1982 I-O Make Table — Summary Version

(millions of dollars in producers' prices)

Commodity/Industry	01	02	03	04	05	06	07	08	09	10	11	12	14	Total Industry Output
01 Agriculture	190,104	0	0	155	4,107	0	921	0	0	0	103	0	0	195,390
02 Mining	0	178,410	0	206	8,765	5,235	0	0	0	0	0	0	0	192,616
03 Construction	0	0	438,791	0	0	0	0	0	0	0	0	0	0	438,791
04 Durable Manufacturing	0	255	0	983,558	3,593	27	0	0	0	0	1,338	0	1,758	990,529
05 Nondurable Manufacturing	0	608	0	4,232	908,406	0	0	0	0	0	32,121	0	405	945,772
06 Utilities	0	117	0	0	557	317,818	0	0	0	0	14,614	108	0	333,214
07 Transportation	0	0	0	0	0	1,759	194,575	0	0	0	0	0	86	196,419
08 Wholesale and Retail Trade	0	0	0	0	0	0	0	577,029	0	0	0	0	0	577,029
09 Finance, Insurance, and Real Estate	0	0	0	0	0	0	0	0	714,958	0	872	0	0	715,830
10 Eating and Drinking Places	0	0	0	0	0	0	0	0	0	143,035	0	0	174	143,209
11 Services	0	0	0	0	0	0	0	0	528	0	750,041	0	0	750,569
12 Government Enterprises	0	0	0	27	0	29,340	4,464	2,882	4,607	1,514	810	34,005	0	77,649
14 Scrap and Special Industries	0	0	0	0	0	0	0	0	0	0	0	0	382,755	382,755
T Total Commodity Output	190,104	179,390	438,791	988,178	925,428	354,179	199,960	579,911	720,093	144,549	799,899	34,113	385,178	5,939,772

Note: Read column for commodity output. Read row for industry output. Detail may not add due to rounding.

Table C2.—1982 I-O Use Table — Summary Version

(millions of dollars in producers' prices)

	Industry/Commodity	01	02	03	04	05	06	07	08	09	10	11	12	14	Total Intermediate Use	Final Demand	Total Commodity Output
01	Agriculture	55,652	6	486	4,399	82,095	26	18	171	3,023	2,638	1,163	2,124	0	151,801	38,304	190,104
02	Mining	254	8,956	2,578	10,072	137,669	52,831	221	28	0	6	39	1,769	0	214,423	-35,032	179,391
03	Construction	1,812	4,749	452	7,248	2,375	12,350	5,367	3,711	25,686	663	12,024	10,177	0	86,612	352,179	438,791
04	Durable Manufacturing	3,848	7,714	116,219	333,553	43,360	9,134	7,693	5,902	3,005	2,825	41,577	2,598	0	577,428	410,749	988,177
05	Nondurable Manufacturing	31,367	3,963	24,349	56,625	247,092	9,164	27,794	22,333	7,638	41,325	39,990	6,292	0	517,931	407,497	925,428
06	Utilities	3,235	5,294	2,993	33,714	31,804	63,134	4,411	23,372	8,660	4,443	21,668	11,445	0	214,171	140,009	354,180
07	Transportation	3,766	905	8,465	21,874	26,941	5,655	26,730	5,957	5,721	2,124	6,947	3,195	0	118,281	81,679	199,960
08	Wholesale & Retail Trade	6,711	1,801	32,486	56,279	37,787	1,829	4,222	7,736	1,406	7,333	14,990	2,137	0	174,717	405,194	579,911
09	Finance, Insurance, and Real Estate	11,504	26,081	4,588	13,051	10,190	7,072	6,399	29,579	101,008	7,079	43,665	1,347	0	261,563	458,530	720,093
10	Eating and Drinking Places	109	277	1,296	4,392	3,132	878	2,068	11,973	8,205	826	5,756	224	0	39,135	105,413	144,549
11	Services	4,870	4,743	38,591	41,514	36,255	11,300	9,597	59,576	32,080	9,390	74,908	1,817	0	324,641	475,259	799,900
12	Government Enterprises	151	61	273	2,260	3,319	820	350	3,017	5,293	403	4,744	688	0	21,376	12,736	34,113
13	Noncomparable Imports	19	438	2	4,907	5,791	1,946	5,369	1,426	1,431	60	1,753	730	0	23,873	-23,873	0
14	Scrap & Special Industries	0	0	6	4,744	864	23	42	0	0	0	545	2	0	6,226	378,953	385,179
I	Total Intermediate Inputs	123,297	64,987	232,783	594,633	668,674	176,162	100,281	174,780	203,155	79,115	269,766	44,542	0	2,732,176	0	
VA	Value Added	72,093	127,627	206,008	395,897	277,099	157,052	96,138	402,249	512,676	64,094	480,804	33,108	382,755		3,207,597	
T	Total Industry Output	195,390	192,615	438,791	990,529	945,773	333,214	196,419	577,029	715,831	143,209	750,570	77,650	382,755			5,939,773

Note: Read column for industry output. Read row for commodity output. Detail may not add due to rounding.

*U.S. G.P.O.:1993-343-273:80197

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